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Aircraft Wire System Laboratory Development: Phase I Progress Report

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Abstract

An aircraft wire systems laboratory has been developed to support technical maturation of diagnostic technologies being used in the aviation community for detection of faulty attributes of wiring systems. The design and development rationale of the laboratory is based in part on documented findings published by the aviation community. The main resource at the laboratory is a test bed enclosure that is populated with aged and newly assembled wire harnesses that have known defects. This report provides the test bed design and harness selection rationale, harness assembly and defect fabrication procedures, and descriptions of the laboratory for usage by the aviation community.

Acknowledgement

This project is being supported through an Interagency Agreement: DTFA-03-00X90019 and is sponsored by Robert Pappas of the Federal Aviation Administration (AAR-433). Many individuals provided their expertise in supporting development of the laboratory including peer reviews involving Sandia inter-departmental staff. The authors would like to acknowledge the time, guidance, and resources spent by the following individuals: Larry Schneider, Chuck Pritchard, Jim Spates, Paul Smith, Jim Puissant, Jeff Kellog, Rob Bernstein, Floyd Spencer, Gerry Langwell, Marilyn Bange, Joe Rudys, Parris Holmes, Leonard Martinez, Dennis Roach, David Moore, Mike Ashbaugh, Mike Bode, and Dick Perry. Even though he is a coauthor, it is appropriate to again acknowledge Chris Lopez's dedication to development of the laboratory.

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Introduction

Because of aged wiring concerns for commercial passenger aircraft, the Federal Aviation Administration (FAA) has sponsored development of a laboratory to support the commercial aircraft industry in the evaluation and development of nondestructive inspection (NDI) wire diagnostic techniques. The laboratory is in development at the FAA's Airworthiness Assurance NDI Validation Center (AANC), operated by Sandia National Laboratories. The laboratory goal is to provide the FAA and industry with capabilities to begin comprehensive evaluations of new and existing diagnostic inspection and monitoring methods for aircraft wire systems. In November 2002 an initial test bed came on-line. The test bed is populated with aged and newly assembled wire harnesses containing various types and severities of wiring anomalies. The test bed has already been used by several industry developers of wire system diagnostics and has additional users scheduled. This report documents the design rationale and capabilities of the aircraft wire system laboratory.

Background

The Aging Transport Systems Rulemaking Advisory Committee (ATSRAC) sponsored a survey of aircraft wire systems that included Boeing 727, 737, and 747 and Douglas DC-8, DC-9, and DC-10 commercial passenger aircraft. These surveys (ref.1) found wire-defect types that included insulation and shield chafing, wire insulation breaches, varying degrees of insulation cracks, insulation enbrittlement, conductor damage, over-pressured harness clamps, excessive bend radius, chemical corrosion, heat-induced insulation charring, faulty wire splices, and faulty terminating connector assemblies.

A wiring system test bed was developed and contains wire harnesses that were extracted from the above-mentioned aircraft types. Both naturally occurring and fabricated defects of the types identified in the ATSRAC reports are present in the sample wire harnesses. The test bed also has newly assembled wire harnesses, using Boeing and Douglas wire harness assembly and installation procedures, Mil-Spec tooling, and other good wiring practices (refs. 2–5). The aged wire harnesses (extracted from retired aircraft) have been selected from various locations consistent with the surveys in the ATSRAC reports. These locations include the electronics bay and rear face of the cockpit breaker panels; wheel well areas; leading and trailing wing edges; rear cargo bay (under lavatory and galley); rear fuselage; and tail cone sections. Wire harness samples from the pressurized passenger cabin areas are also included.

The test bed is an aluminum enclosure that has five levels of trays containing 40 harnesses and can readily accommodate dozens more per tray. The harnesses are routed on Boeing 727–737 dimensioned air-frame segments (ribbed structure, with curvature). Included in the enclosure is a tray reserved for precision transmission lines, for calibrations purposes; and a tray reserved for more complex wiring system installations (branching, distribution panels, powered systems). The test bed harness enclosure is described in detail in the next section.

The laboratory development project is a three-year effort. The first-year task of bringing on-line a test bed capability was met in November 2002. The test bed contains the rudimentary wiring defects mentioned above. The second-year tasks include development of a humidity-controlled harness test chamber, installation of wire system components/systems (such as arc and current fault circuit breakers) in the reserved test bed trays, and provision of additional/upgraded defect types, including very long harness lengths. The third year will include adjustments/improvements to the laboratory based in part on recommendations from aviation community diagnostic developers and users.

Test Bed Enclosure Design

The test bed enclosure design is a modular, metallic enclosed structure that has several levels of trays for wire-harness placement. A modular design was selected for the following reasons:

- allows attachment of additional enclosures to accommodate longer harness lengths and provides powered electrical/avionic systems connected to harnesses

- permits different/additional tray levels for wire system simulation purposes

- provides a good electrical reference for instrumentation

- permits addition of hermetic seals to have controlled environments, such as humidity, temperature, electromagnetic noise, and corrosive contaminates from the variety of chemicals and fluids used on commercial passenger aircraft.

The enclosure is made of an aluminum strut frame with aluminum flat panels (1/8 inch thick) attaching to all sides. It is 10 feet in length and 5 feet in height. The general dimensions of the side, top and bottom panel(s) will be 5 x 5 sq-ft. The dimensions of the panels at the front and rear (enclosure width) will be 5 feet in width and 1 foot in height. Figure 1 shows a detailed drawing of the enclosure. The strut frame structure support four additional flat panels spaced at a height of 1 foot. Figure 2 is a photograph of the enclosure at a partial level of assembly. It can be seen in Figure 2 that the lower four cable trays provide a ribbed-structure, metallic ground-plane for harness support and electrical characteristics related to transmission lines. These segments were made by Foster and Miller Metal Works and are used in the test bed. The segments were fabricated to represent Boeing 727 and 737 aircraft ribbed-fuselage structure. Figure 3 is a photograph of a sample segment.

The removable panels are a quick-connect–disconnect type. The front and rear panels have penetrations to allow harness termination connector panel mounts. The dimensions of these penetrations are in accordance with selection of specific connector types. Lifting portals are welded to the bottom exterior of the enclosure for transportation purposes. The enclosure is mounted on three pairs of neoprene castors for mobility. The fully enclosed test bed is shown in Figure 4. Trays are labeled from 1 to 5, with 3 rows and 22 columns for harness placement per tray.

In addition to the enclosure drawing shown in Figure –1, a complete set of Pro-E→ design drawings is available for additional enclosure fabrication and costing purposes.

Wire Harnesses Types

The test bed has retired and newly fabricated harnesses that include single- and multi-conductor insulated wires that are twisted with and without shielding. Wiring ranges from high-current power cables (awg 8) to small-diameter signal wires (awg 22). Figure 5 is a photograph of inventoried harnesses from Boeing and Douglas retired aircraft. These aged harnesses were obtained from several locations on the aircraft including the EE bay, wheel wells, wing edges, cargo sections, and fuselage. All extracted harnesses are tagged for identification of in-service location and aircraft number, and they were documented on videotape prior to removal. Annex A lists the harnesses acquired.

Based upon the ATSRAC reports, an initial selection of newly fabricated wire harnesses includes the following wire types: polyimide, Mil-W-81381; PVC/GN, Mil-W-5086/1,2; Poly-X, Mil-W-81044/16; and XL-ETFE, Mil-W-22759/32 to 46. Annex B provides a detailed description of each wire type with illustrative diagrams. Newly fabricated harnesses are assembled in accordance with Boeing and Douglas documents (ref. 2, 3), using military specified tooling (ref. 4), by an IPC–A–610C certified technician (ref. 6). Figure 6 is a photograph showing a typical wire and connector just prior to final assembly. Annex C lists all connectors used (new or acquired from aircraft) in the test bed. These fabricated harnesses will be installed in the test bed with typical features such as ties, clamps, branching, and grounding lugs. Users of the test bed are sent a complete description of each harness that includes connector type (model #), each wire type (military or manufacturer #), and a photograph of connectors for each harness (bow and aft) with the pin numbering pattern entered. Annex D provides this listing.

Wire Anomalies Fabrication

An important task of the first year project was the development of techniques to simulate a range of defects in a reproducible manner, including varying degrees of insulation or conductor damage for a specific defect type. The following wire defect types are included in the test-bed wire system:

- Wires with opened or broken conductors
- Wire insulation chafed to various degrees
- Breached wire insulation
- Cracked or brittle insulation
- Partial strand-conductor breakage
- Over-pressured wire fastener clamps
- Wires with excessive bend radius
- Heat induced or chemically corroded wire damage
- Faulty wire splices
- Faulty connectors.

For each defect type, a specific fabrication procedure was developed. A defect descriptor chart is provided in Table 1 and describes the defect type and severity. Annex E documents these procedures with illustrative photographs. The procedures were developed and documented in sufficient detail to allow accurate reproducibility. Figure 7 shows a sample using these procedures to fabricate defects. The tools used in these procedures are a standard wire stripper, feeler gauges, and a common knife for insulation cutting. A Dremel tool is also used to produce abraded or chafed wire insulation or metallic shielding. Other defect fabrication tools include a torque wrench for creating over-pressured clamps and a heat gun with a wire-positioning fixture for producing charred insulation. These procedures permit consistency of a given diagnostic method to detect and locate similar as well as different types of defects. Defect procedures, severities, and types are modified based on comments/recommendations made by the community users. Photographs of all the defect types present in the test bed are shown in Annex F.

Test Bed Characterization

The placement and type of defects in the wires have been documented at the AANC and Sandia. This information is not available to users of the wire system laboratory. Additional characterization of the wire harnesses using transmission line parameters in terms of per unit length resistance (R), inductance (L), capacitance (C), and conductance (G - resistive loss through the insulation material) will also be documented for supporting user investigations. Characterization of the harnesses in terms of transmission line parameters will be carried out after installation of well-defined transmission line geometries being designed into the first or top tray of the test bed enclosure. Characterization of these transmission lines first, using standard commercial instrumentation, will permit a validated method for characterizing the test bed aircraft harnesses. The well-defined transmission line types used for harness characterization calibration are single and twin flat-wire conductors imbedded in polyethylene and nylon, and single and uniform twin-axial coaxial-shielded cables. Polyethylene and nylon have relative dielectric constants ranging from 2.1–2.3 and 4.2. Both single and two-conductor configurations are needed for common (wire-to-airframe) and differential (wire-to-wire) mode purposes. An Agilent 4294A Impedance Analyzer is being used for frequency domain measurements of these parameters (not to investigate the capability for defect detection). Similarly, a Tektronix time domain reflectometry (TDR) model 1502C is being used to corroborate this information for both differential and common mode parameters within the harnesses.

When it is established that these transmission line parameters are well defined, it is intended to place minute insulation defects into the transmission lines to support users in determining sensitivity thresholds of their diagnostic instrumentation.

Wire System Laboratory Usage

Use of the wire laboratory and test bed is scheduled through the AANC facility manager, Gerald Langwell (Sandia National Laboratories, Albuquerque, NM). A short user request form will be sent to scheduled visitors prior to arrival and addresses equipment needs, safety issues or other participant requirements. The AANC will provide support, when requested, such as working space, tables, electrical power cords, ladders, maintenance stands, common hand tools, etc. These and other required tools or hardware must be identified prior to visits. Users will also be sent a description of each of the harnesses in the test bed (see listing in Annex D) and supplied with a complete description of the state of the test bed. At the laboratory, displays provide a hands-on and visual aid of the harness type, pedigree, construction and assembly procedures. These displays include:

- Aged/retired harness pedigree
- Illustrations of wire descriptions
- Defects fabrication procedures
- Photographs of defect types
- Wire-to-pin/socket-to-connector assembly and actual wire defects.

Upon completion of testing, each user is required to document preliminary results of a given diagnostic process on an AANC supplied wiring anomaly form, a sample is provided in Table 2. The intent of this form is to provide an initial/preliminary document to the AANC on results and also serves as a duplicate record. Note that the number of anomalies is reduced to three categories to simplify particular defect type (DT – defined in Table 1) identification. Also note that the form encourages the user to make a recommendation (based on the diagnostic results) on whether a maintenance action is required, or requires further inspection. The AANC provides an information sheet on what a user reports on the condition of each wire compared to actual wire anomalies that are present. This information is supplied only to the user and the AANC sponsor. A sample AANC Graded Report Summary is shown in Table 3. Both these forms are discussed during the visitor orientation briefing.

There is no requirement for users of the wire laboratory to provide details of their technology to AANC personnel. However, if a need or circumstance arises that requires some degree of informing AANC personnel on how particular methods or instrumentation operate, users of the wire laboratory that have proprietary methods and instrumentation can request AANC personnel to execute non-disclosure agreements. Such agreements will require review by Sandia legal personnel, so advance coordination is recommended. This has effectively been carried out numerous times since the inception of the AANC facility. The AANC performs unbiased technology evaluations with equal consideration of all technologies regardless of their origin, sponsorship or ownership.

All Department of Energy (DOE) developed technologies to be evaluated at the AANC will be carried-out by two evaluators that are independent of the DOE and the AANC. One evaluator will receive adequate training on the use of any DOE developed technology, and a second independent evaluator will execute a non-disclosure agreement for use of the wire laboratory defects log-book necessary for performing post-test data analysis.

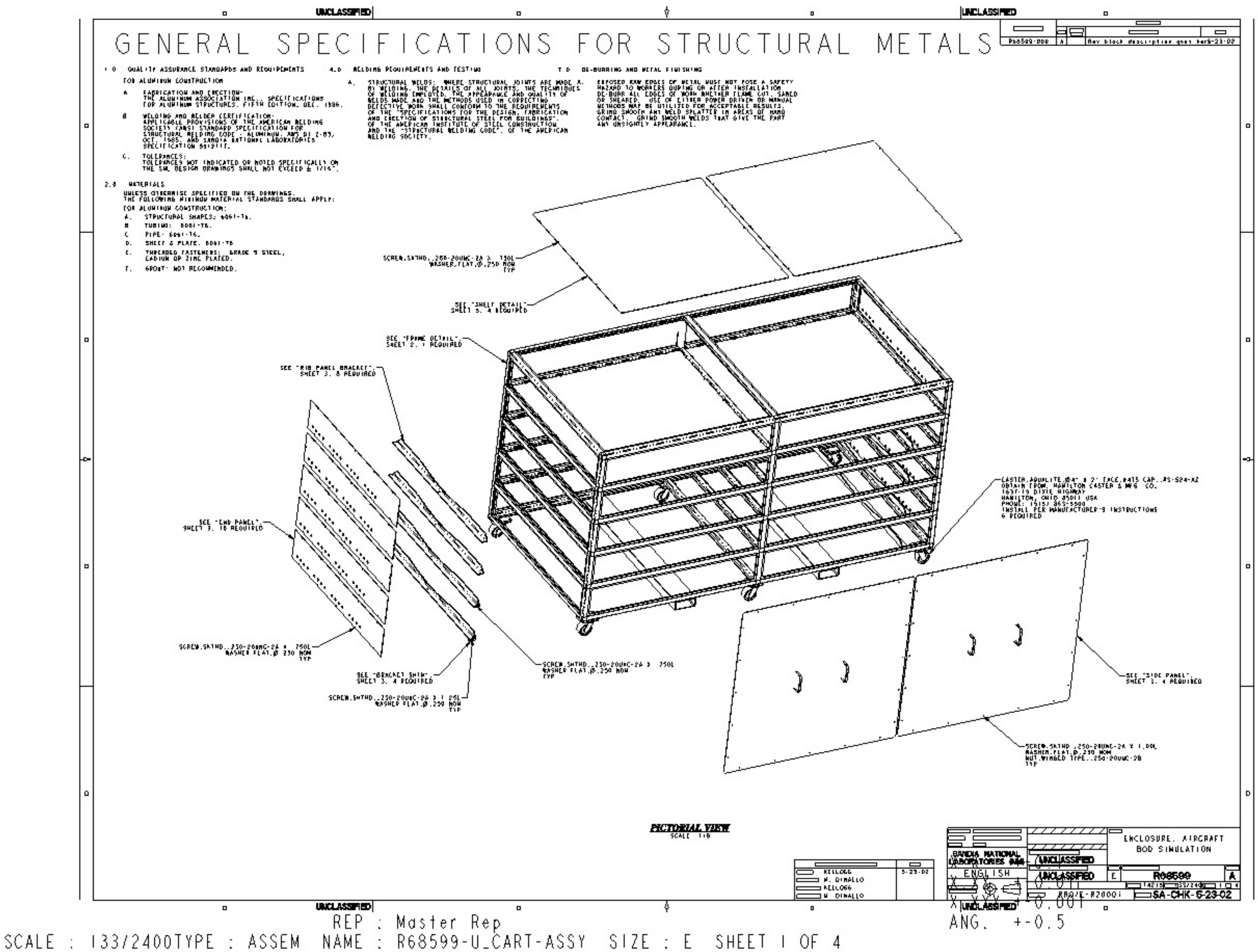


Figure 1. Design Drawing of Test Bed Enclosure

Figure 2. Partially Assembled Wire Harness Enclosure

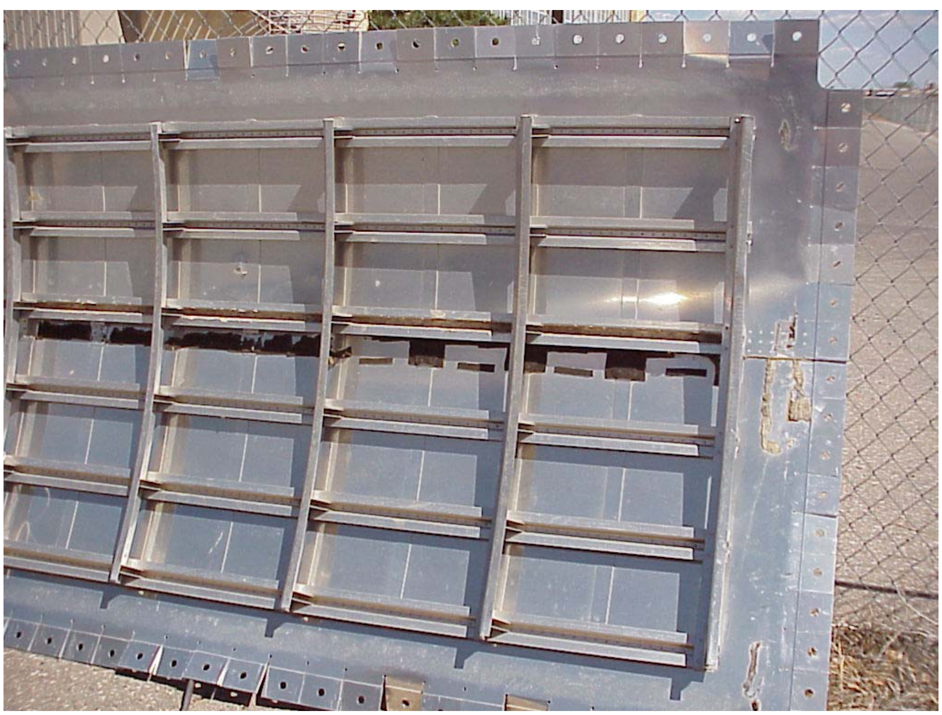


Figure 3. Boeing 727/737 Type Ribbed-Structure Segment Fabricated by Foster-Miller

Figure 4. Assembled Wire Harness Enclosure

Figure 5. Extracted Harnesses from Retired Aircraft

Figure 6. Wire Harness to Connector Assembly Display

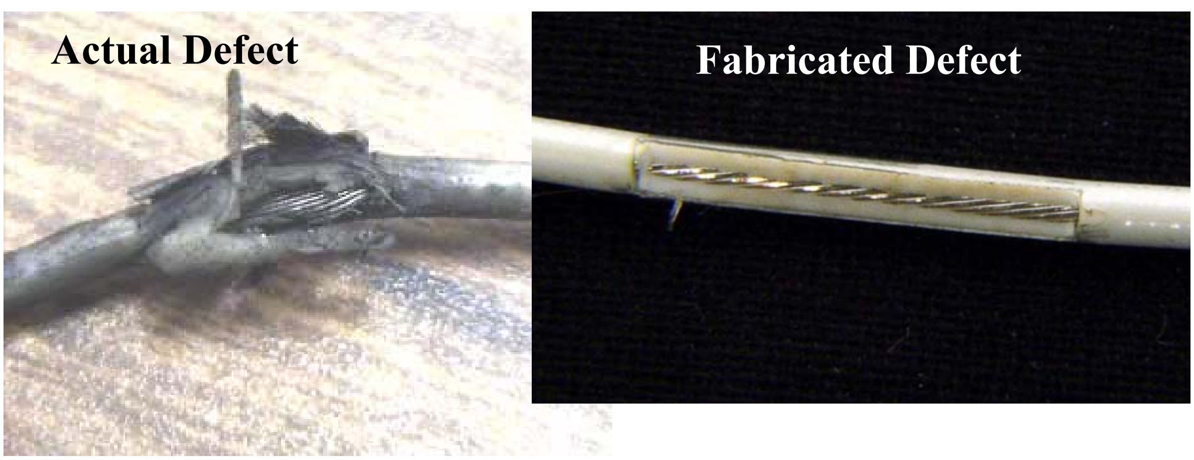


Figure 7. Comparison of Actual and Fabricated Defects Using Annex E Procedures.

Table 1. Defect Descriptor Table

Defect Type	Identifier Code	Severity Code	Comments (Parameter Data)
Abraded or Chafed Insulation	DT1	% of Insulation Radius Removed, Linear Extent, Angular Extent	Severe: 100%, 1”, 180^0 Medium: 100%, 0.25”, 90^0 Minute: 50%, 0.5”, 90^0
Breached Insulation (360^0 Exposed Conductor)	DT2	Linear Extent,	Severe: 1” Medium: 0.125” Minute: 0.03125”
Cracked Insulation	DT3	Linear Extent, Density, % into Insulation	Severe: 4”, 100/inch, 100% Medium: 1”, 25/inch, 100% Minute: 1”, 5/inch, 50%
Conductor-Strand Breaks	DT4	% of Strand Breaks (with no contact)	Severe: 75% Medium: 25% Minute: 5%
Over-Pressured Clamps	DT5	Clamp Specification, Torque Applied	Severe: 100 inch-lb Medium: 50 inch-lb Minute: 25 inch-lb
Bend Radius	DT6	Degrees from Initial Routing	Severe: 180^0, No Loop Area Medium: 180^0, Harness Separation 2x Diameter Minute: 180^0, Harness Separation 5x Diameter
Faulted Splices	DT7	No Crimp, Too Many Splices, Exposed Conductor	Type I: Insulation Heat Shrunk, No Crimp Applied Type II: Exposed Wire-To-Wire Joining Type III: Over-Heated Insulation Shrinkage Type IV: Too Many Crimps per Wire
Heated Insulation	DT8	Heating Duration, Temperature	Severe: Blacken, Frayed Insulation Medium: Blacken, Contorted Insulation Minute: Slight Discoloration, Insulation Not Contorted
Conductor Opened	DT9	With Contact (WC), No Contact (NC)	Severe: No Contact Medium: 50% Contact Minute: 90% Contact
Conductor Shorted	DT10	Moderate or Hard Contact	Severe: O-Lug Torqued To Rib, Wire-to-Wire Soldered Medium: Same as Severe with 0.1-Ω Intervening Minute: Same as Severe with 10-Ω Intervening
Corrosion	DT11	Light, Medium, Severe	In Progress

Table 2. Sample Preliminary User Provided Report
AANC Test Bed
Wiring Anomaly Report

	Harness Location (Tray , Row, Col)	Connector (Bow, Aft) (Model #)	Anomalous Wire/Pin ID	Anomaly Categories Insulation (DT 1-3, 8); Continuity (DT 4,7, 9, 10); Installation (DT 5, 6)								
				#1	Severity	Action	#2	Severity	Action	#3	Severity	Action
1	2, top, 19	Bow	1 to 13	Continuity	Open	Visual						
		MS24264R16B24PN		96” from Aft		Inspect						
			17 to gnd	Insulation	Unknown	Visual						
				57” from Bow		Inspect						
2	2, top, 21	Aft	7 to 16	Installation	Minute	No						
		MS24266R20B39P8		53” from Bow		Action						
3	3, top, 8	Aft	16 to gnd	Insulation	Exposed	Visual	Installation	Unknown	Visual			
		MS24266R18B8PN		23” from Aft	Conductor	Inspect	64” from bow		Inspect			
4	4, top, 5	Bow	27 to 41	Continuity	Short	Visual						
		MS24264R22B55P7		19” from aft		Inspect						
5	4, top, 13	Bow	7 to 1	Insulation	Aged	No						
		MS24264R14T7P6				Action						

Personnel:____________ Company:_____________ Date:_______________ Technology:_____________________

Comments:____

Table 3. Sample AANC Report Summary

Visitor: XYZ Corp (Personnel: Engineer; Technician)
Date of Visit: November 14 –15, 2002 **AANC/Sandia Personnel:** Christopher Lopez, Mike Dinallo
Test Objective: Demonstrate ability of diagnostic system to locate defects (model – first product, serial # 42b).
Test Conditions: Tested all enclosure harnesses. (Relative Humidity 33%, Temperature 75^0F)

Harness Location (Tray, Row, Column)	Harness Types (General Description)	Connector[1] Accessed For Testing	Pins Evaluated	Detected Defects (Pin)	Reported Wire Condition (Type : Severity/Value : Location (inches)) Actual	Diagnostic Result	Comments
3, 2, 14	17 pins, single and STP[2] wires	Aft	17 - pins	6, 9	6 to 9: shorted: 37”	6 Shorted to 9: <10mΩ : 37”	Identified shorts of pins evaluated except missed 1 shorted defect
4, 3, 2	5 pins, only single wires	Bow	5 - pins	2 4	Insulation breach : severe: 96” bend radius: severe : 53”	insulation: severe: 103” installation: severe : 53”	Identified anomalies of pins evaluated
2, 3, 6	24 pins, only single wires	Bow	24 - pins	13 7	continuity (DT4):medium:73” open: hard : 87”	continuity : NR : 73” opened: > 1MΩ: 83”	Identified anomalies of pins evaluated
3, 3, 22	55 pins, single and STP[2] wires	Aft	55 - pins	23, 32, 14	Heated insulation:severe:107”	insulation: NR : 107”	Identified anomalies of pins evaluated Other evaluated wires/pins had defect(s) not identified

[1]All connector types are rotate-to-snap (lock-in), pins or socket, loose or panel mount.
[2]Shielded Twisted Pair. [3]Severity Not Reported.

General Observations: Out of 101 pins/wires evaluated, having 13 anomalous conditions, 4 were undetected; the locations had errors less than ±5%. Approximate diagnostic measurement time was 8 hours.

Disclaimer: The information provided does not constitute endorsement or validation of any diagnostic equipment or methodology by the FAA, Sandia, the DOE or any of its contractors.

References

1. *Intrusive Inspection Final Report,* December 2000, and the *Aging Transport Systems Task 1 and 2 Final Report*, August 2000. Both reports were sponsored by the Aging Transport systems Rulemaking Advisory Committee, chartered by the FAA. http://www.mitrecaasd.org/atsrac/index.html.

2. Boeing Company, *D6-36911 Electrical Wiring Assembly and Installation Procedures,* 9-26-96.

3. *Douglas Process Standard Individual Commercial Aircraft Electrical Installation,* DPS 1.834, 8-2-91.

4. Military Specification DTL 22520G and Mil-C-22520/1 – 39, Crimp Tools, Wire Terminations, General Specifications, September 12, 1997.

5. *FAA Advisory Circular 43.13-1B*, Chapter 11, 9-8-98.

6. "Acceptability of Electronics Assemblies," Association Connecting Electronics Industries, IPC-A-610C Standard, January 2000.

Annex A
Listing of Acquired Aircraft Harnesses

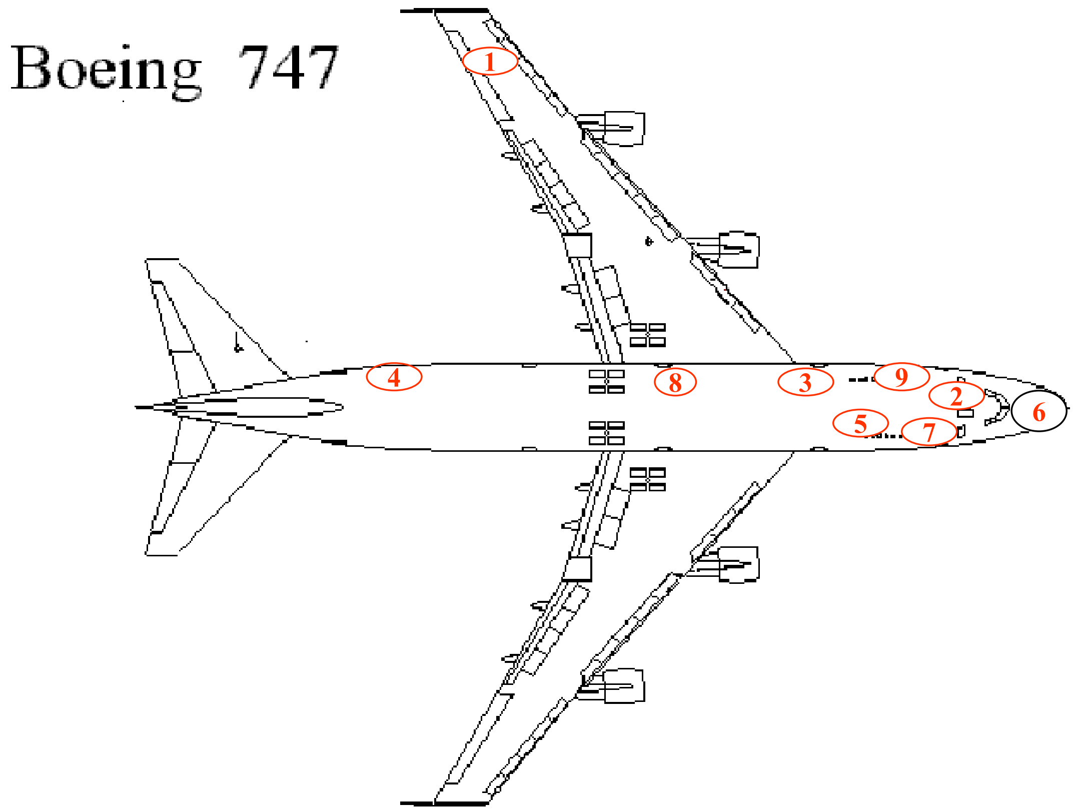
This annex contains a listing of wire harnesses extracted from retired aircraft. Aircraft manufacturer, model-type, specific plane tail number, and in-service location are provided.

Acquired Harness Listing

Harness ID	Aircraft Number	Location
61	747 N306TW	Left wing clip
62	747 BL8751	Body Station 560
63	747 BL8751	Body Station 740-760
64	747 N306TW	Body Station 2220
65	747 N306TW	Right Wing Station WS 450
66	747 N306TW	Right Wing Station XFS 280
67	747 N306TW	Right Wheel Well Station WS 425
68	747 N306TW	Right Body Gear Station 1241
69	747 N306TW	Body Station 2220
70	747 N306TW	Body Station 400
71	DC-9 N923L	Fuselage Station 1087
72	DC-9 N923L	Fuselage Station 617
73	DC-9 N923L	Right Main Wheel Weel
74	DC-9 N923L	Fuselage Station 768
75	DC-9 990	Engine Paylon Station 1020
76	DC-9 N923L	Right Main Wheel Well
77	DC-9 990	Engine Paylon Station 1020
78	DC-9 990	Engine Paylon Station 1020
79	DC-9 990	Engine Paylon Station 1020
80	DC-9 N923L	Rear Fuslage Station 937

Acquired Harness Listing (Continued)

Harness ID	Aircraft Number	Location
81	DC-10 1154 TW	Aft Face of Cocpit Breaker Panel
82	DC-10 1154 TW	Aft Fuselage Compartment (left front side station 1600-1640)
83	DC-10 1154 TW	Aft Fuselage Compartment (left front side station 1599-1585)
84	DC-10 1154 TW	Left Side Trailing Wing Edge (station 772 zone 536)
85	DC-10 1154 TW	Cargo Section (left side to flight recorder) (station 1851)
86	DC-10 1154 TW	Bottom Cargo Section (in bottom) (station 1850)
87	DC-10 1154 TW	Right Wheel Well Gear Zone
88	DC-10 1154 TW	Right Wheel Well Gear Zone
89	DC-10 1154 TW	Electronics Bay (right side aft A and E bay)
90	DC-10 1154 TW	Electronics Bay

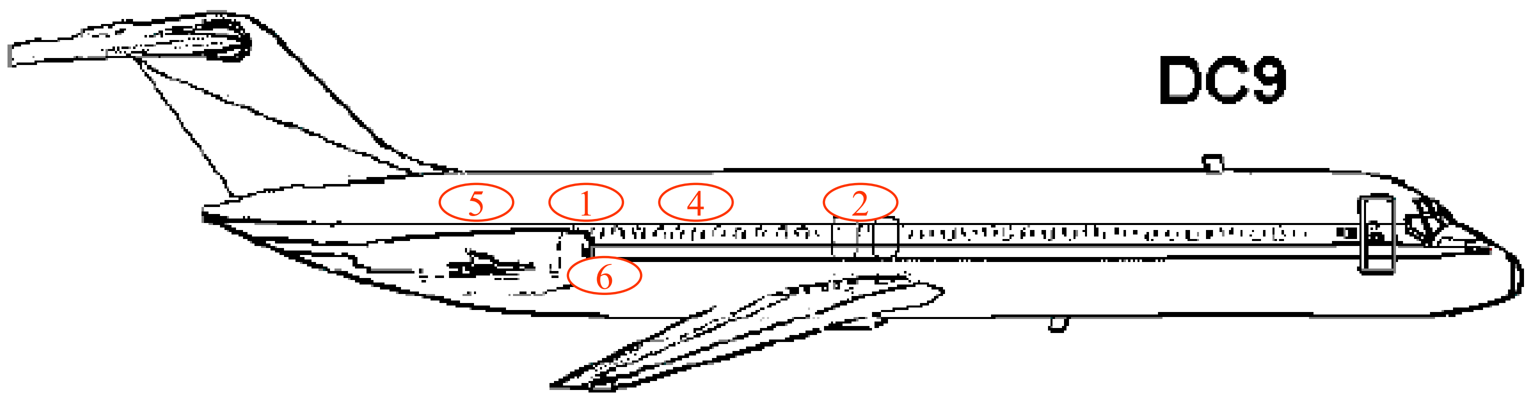


1: 61; Left wing clip | 4: 64 & 69: Body STA 2220 | 7: 67: Right Wheel well STA 425

2: 62; Body STA 560 | 5: 65: Body STA 450 | 8: 68: Body gear STA 1241

3: 63; Body STA 740 | 6: 66: Body STA 280 | 9: 70: Body STA 400

Figure A.1. Zones Where Harness IDs 61–70 Were Extracted



1: 71: Fuselage Station 1087

2: 72: Fuselage Station 617

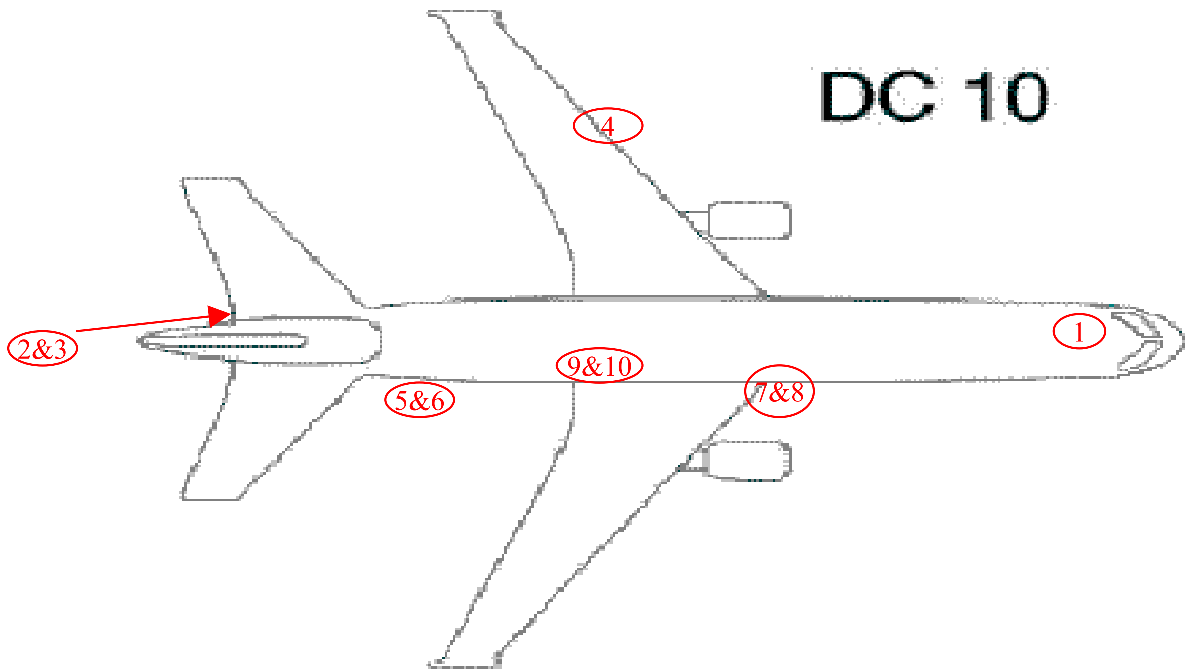
3: 73 & 76: Right Main Wheel Well

4: 74: Fuselage Station 768

5: 75, 77, 78, 79: Engine Pylon Station 1020

6: 80: Rear fuselage Station 937

Figure A.2. Zones Where Harness IDs 71–80 Were Extracted



1 : 81 : Aft face cockpit panel

2 : 82 : Aft fuselage compartment 1600-1640

3 : 83 : Aft fuselage compartment 1599-1585

4 : 84 : Left side trailing wing edge 539

5 : 85 : Cargo section 1851

6 : 86 : Bottom cargo section 1850

7 : 87 : Right wheel well landing gear zone

8 : 88 : Right wheel well landing gear zone

9 : 89 : Electronics bay (right side aft)

10 : 90 : Electronics bay (right side aft)

Figure A.3. Zones Where Harness IDs 81–90 Were Extracted

Annex B
Description of Wire Types

This annex provides a description of each of the wire types used to fabricate new wire harnesses. Insulation materials, conductor type, and drawings illustrating the wire construction are provided.

Wire Specifications (1 of 2)

Mil Spec #	AWG	Jacket	Additional Layer	Insulation	Conductor
M22759/32-18-9	18	No Jacket	na	Crosslinked ETFE (Ethylene-tetrafluoethylene copolymer)	Tin Coated Copper
M22759/32-20-7	20	No Jacket	na	Crosslinked ETFE (Ethylene-tetrafluoethylene copolymer)	Tin Coated Copper
M22759/32-22-9	22	No Jacket	na	Crosslinked ETFE (Ethylene-tetrafluoethylene copolymer)	Tin Coated Copper
M5086/1-18-9	18	Clear Nylon	na	Polyviny Chloride	Tin Coated Copper
M5086/1-20-9	20	Clear Nylon	na	Polyvinyl chloride	Tin Coated Copper
M5086/1-22-9	22	Clear Nylon	na	Polyvinyl chloride	Tin Coated Copper
M5086/2-18-9	18	Clear Nylon	Glass Fiber Braid with Finisher	Polyvinyl chloride	Tin Coated Copper
M81044/9-20-9	20	Polyalkene-Crosslinked PVDF (Polyvinylidene Flouride)	na	Crosslinked Polyalkene	Tin Coated Copper
M81044/9-22-9	22	Polyalkene-Crosslinked PVDF (Polyvinylidene Flouride)	na	Crosslinked Polyalkene	Tin Coated Copper
M81381/7-20-9	20	Modified Aromatic Polymide Resin Coating	Flourocarbon Polymide Tape	Flourocarbon Polymide Tape	Silver Coated Copper
M81381/7-22-8	22	Modified Aromatic Polymide Resin Coating	Flourocarbon Polymide Tape	Flourocarbon Polymide Tape	Silver Coated Copper

Wire Specifications (2 of 2)

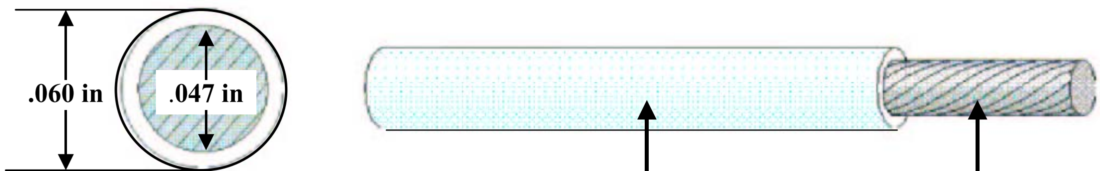
Mil Spec #	Conductor Diameter (inches) Min	Conductor Diameter (inches) Max	Finished Wire Diameter (Inches)	Weight (lbs/1000 ft) (max)	Voltage Rating	Temp Rating	Comments
M22759/32-18-9	.046	049	0.06 ±.002	6.5	600 V	150° C	flame retardent, self extinguishin notch and arasion
M22759/32-20-7	.037	.039	0.05 ±.002	4.3	600 V	150° C	flame retardent, self extinguishin notch and arasion
M22759/32-22-9	.029	.031	0.043 ±.002	2.8	600 V	150° C	flame retardent, self extinguishin notch and arasion
M5086/1-18-9	.046	.051	0.088 ±.004	8.6	600 V	105° C	resistant to water, aircraft fuels,a hydraulic fluid
M5086/1-20-9	.037	.041	0.078 ±.004	6.3	600 V	105° C	resistant to water, aircraft fuels,a hydraulic fluid
M5086/1-22-9	.029	.033	0.068 ±.004	4.4	600 V	105° C	resistant to water, aircraft fuels,a hydraulic fluid
M5086/2-18-9	.046	.051	0.095 ±.005	9.5	600 V	105° C	resistant to water, aircraft fuels,a hydraulic fluid
M81044/9-20-9	.037	.041	0.07 ±.003	5.5	600 V	150° C	flame retardent, self extinguishin notch and arasion
M81044/9-22-9	.029	.033	0.062 ±.003	3.9	600 V	150° C	flame retardent, self extinguishin notch and arasion
M81381/7-20-9	.037	.038	0.050 ±.001	4.3	600 V	200° C	flame retardent,
M81381/7-22-8	.029	.030	0.0425 ±.0015	2.8	600 V	200° C	flame retardent,

MIL-W-22759/32 - 18 - 9

Mil Spec | Gauge | Color

Temp Rating: 150° C

600V



No Jacket

Insulation: Crosslinked ETFE

(Ethylene-tetrafluroethylene copolymer)

Conductor: Tin Coated Copper

MIL-W-22759/32 - 20 - 7

Mil Spec | Gauge | Color

Temp Rating: 150° C

600V

No Jacket

Insulation: Crosslinked ETFE

(Ethylene-tetrafluroethylene copolymer)

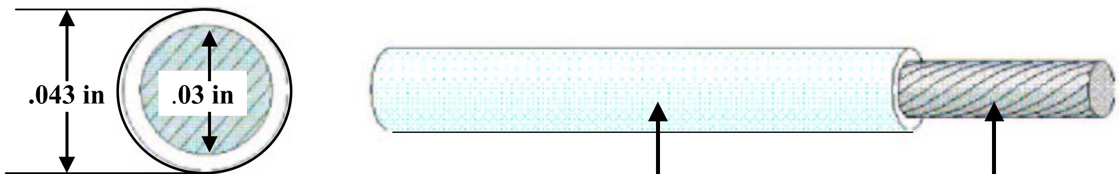
Conductor: Tin Coated Copper

MIL-W-22759/32 - 22 - 9

Mil Spec — Gauge — Color

Temp Rating: 150° C

600V



No Jacket

Insulation: Crosslinked ETFE

(Ethylene-tetrafluroethylene copolymer)

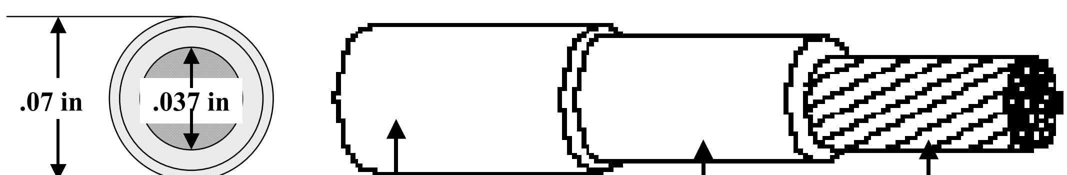
Conductor: Tin Coated Copper

MIL-W-81044/9 - 20 - 9

Mil Spec — Gauge — Color

Temp Rating: 150° C

600V



Insulation: Polyalkene - Crosslinked PVDF
(Polyvinylidene Flouride)

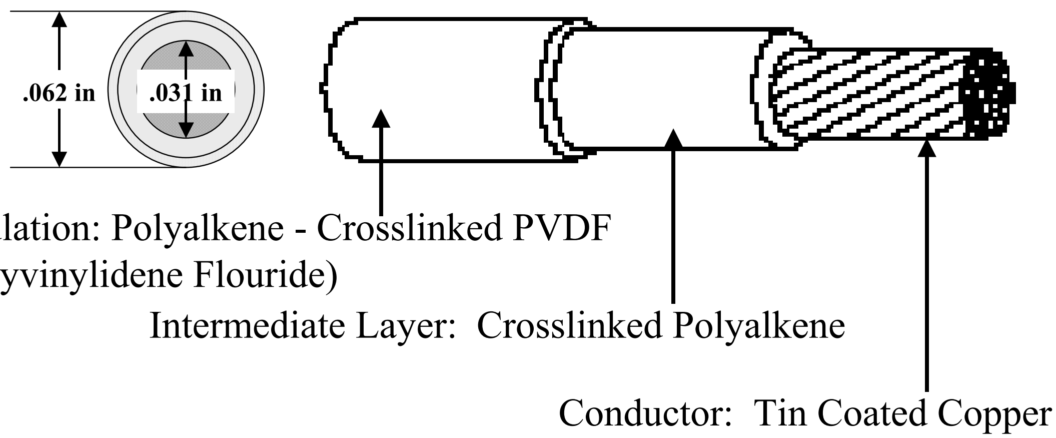
Intermediate Layer: Crosslinked Polyalkene

Conductor: Tin Coated Copper

MIL-W-81044/9 - 22 - 9

Mil Spec | Gauge | Color

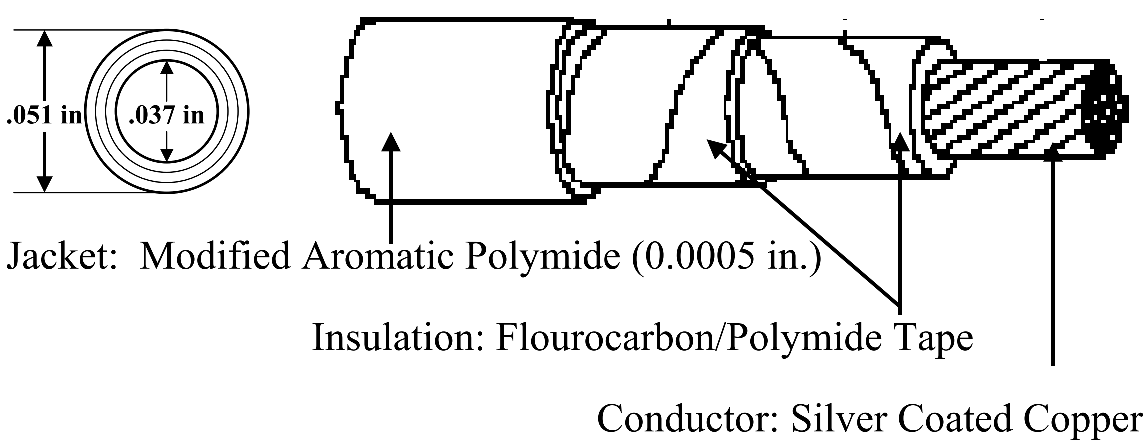
Temp Rating: 150° C
600V



MIL-W-81381/7 - 20 - 9

Mil Spec | Gauge | Color

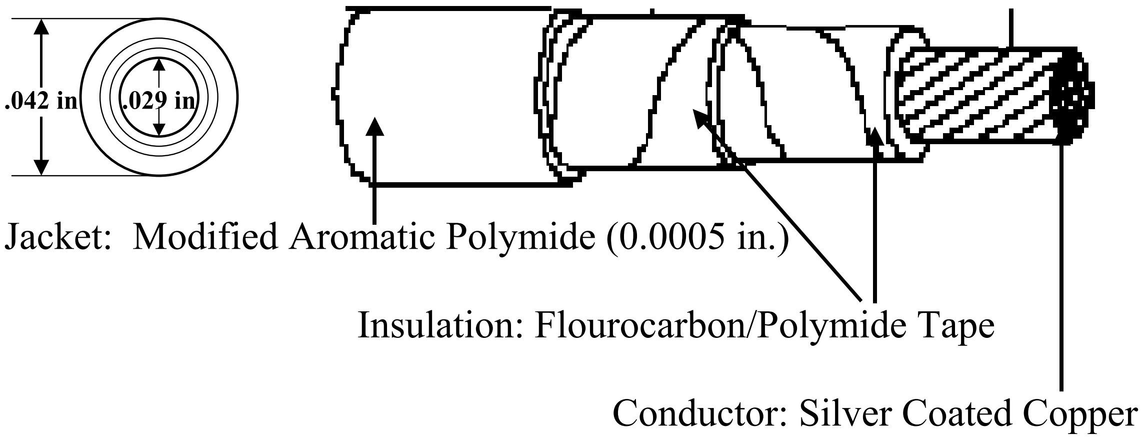
Temp Rating: 200° C
600V



MIL-W-81381/7 - 22 - 8

Mil Spec Gauge Color

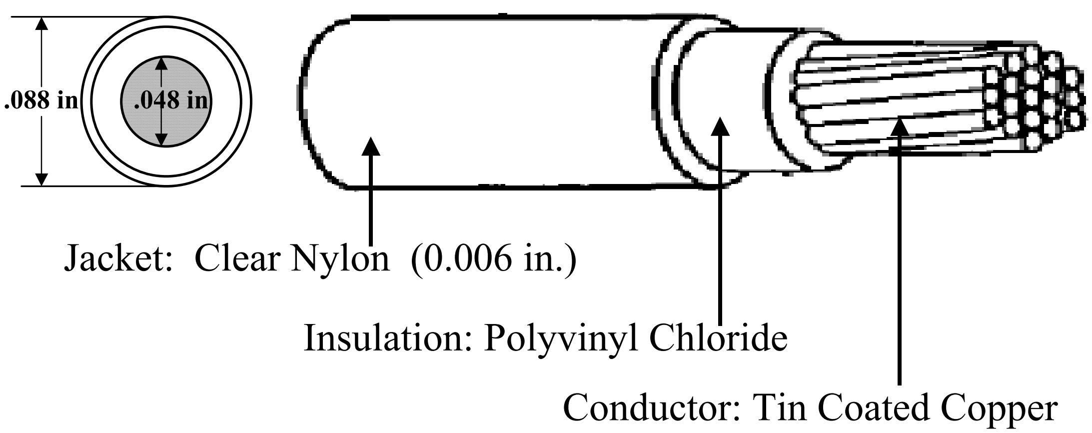
Temp Rating: 200° C
600V



MIL-W-5086/1 - 18 - 9

Mil Spec Gauge Color

Temp Rating: 105° C
600V

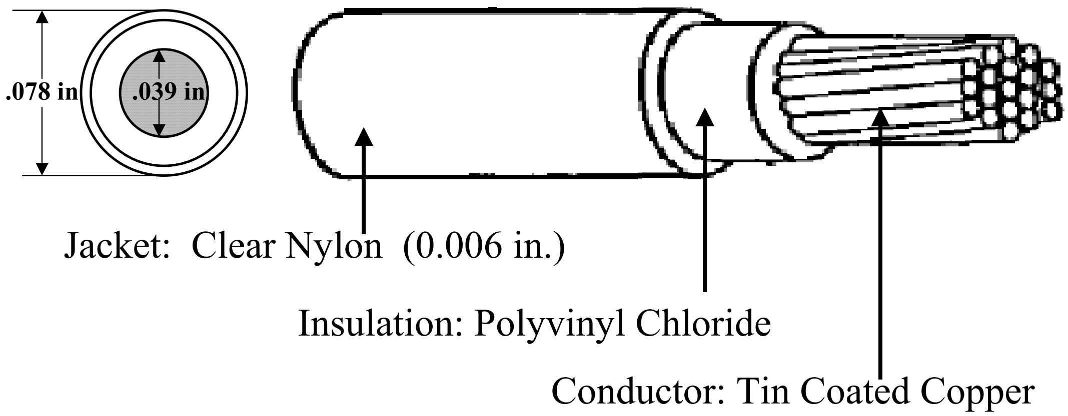


MIL-W-5086/1 - 20 - 9

Mil Spec Gauge Color

Temp Rating: 105° C

600V

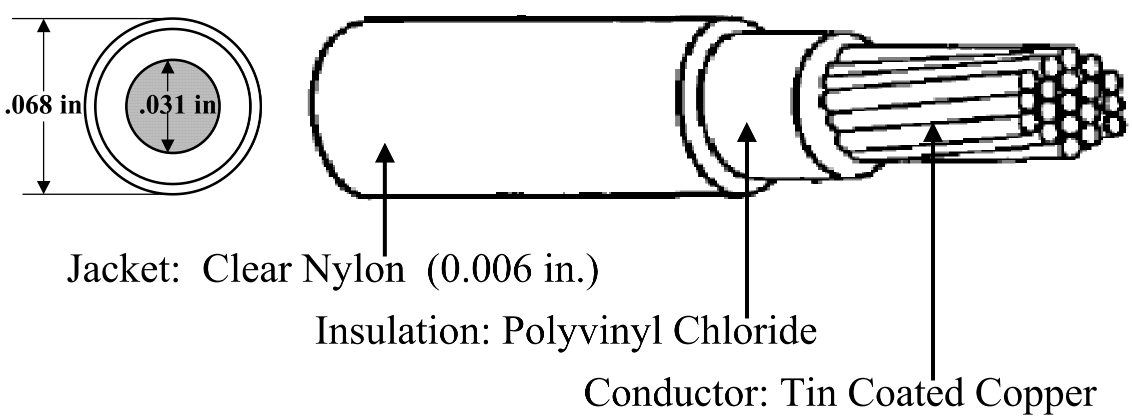


MIL-W-5086/1 - 22 - 9

Mil Spec Gauge Color

Temp Rating: 105° C

600V

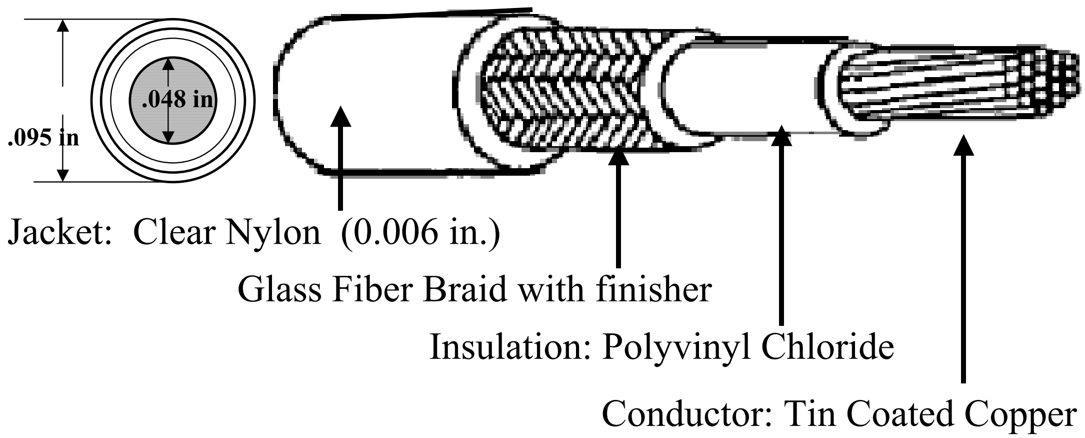


MIL-W-5086/2 - 18 - 9

Mil Spec Gauge Color

Temp Rating: 105° C

600V



Annex C
Connector List

This annex lists each connector model number for newly assembled harnesses, and harnesses retrieved form different aircraft type.

Connectors Used On Test Bed	Serial Number
New Connectors	MS24264R16B24PN
	MS24264R16B24SN
	MS24266R16B24SN
	MS24264R18B31S8
	MS24266R20B39P8
	MS24264R20B39S8
	MS24264R10B5PN
	MS24264R10B5SN
	MS24266R10B5PN
	MS24264R16T4PN
	MS24264R14T7P6
	MS24264R14T7S6
	MS24264R12B12PN
	MS24264R16B15P6
	MS24264R16B15S9
	MS24264R22B19P8
	MS24264R20B25PN
	MS24266R20B25S9
	MS2426422B55PN
	MS2426422B55S8
	MS24266R22B55P8
Retired 747 Acquired Connectors	9229-20
	MS24266R12B12SN
	MS24266R14B15SNX
	MS24266R18B31P8
	MS24266R18B8PN
	MS24266R22B32PN
	MS24266R22B55S7
	ZZL-R-17 24-3D-S06
10 Retired DC-9 Connectors	No Visible # On Any Of Them
10 Retired DC-10 Connectors	No Visible # On Any Of Them

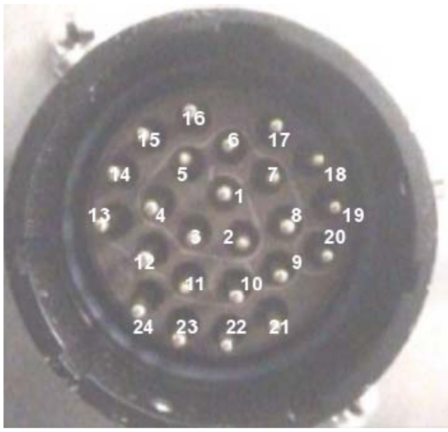
Annex D
Composite Wires and Connectors Harness Descriptions

This annex provides a description of each harness used in the test bed including bow and aft connector type/model number, military or manufacturer specification, and a photograph of both connectors with the pin/wire identification nomenclature.

Harness Connectors In-Situ

Tray 2, Top Row, Column 2

Front: MS24264R16B24PN



Aft: MS24266R16B24SN

Wire Harness Description – Tray 2, Top Row, Column 2

Front Connector: **MS24264R16B24PN**

Aft Connector: **MS24266R16B24SN (Female)**

Front Pin ID	Aft Pin ID	Wire Type	Defect Identified (Type: Severity: Location:)				Comments
1	1	M5086 1-18					
2	2	M22759 32-20					
3	3	M81381 7-22					
4	4	M81381 7-20					
5	5	M81044 9-20					
6	6	M5086 1-20					
7	7	M22759 32-22					
8	8	M81044 9-22					
9	9	M22759 32-18					
10	10	M22759 32-20					
11	11	M5086 1-18					
12	12	M81381 7-20					
13	13	M81381 7-22					
14	14	M5086 1-20					
15	15	M22759 32-18					
16	16	M81044 9-22					
17	17	M81044 9-20					
18	18	M81044 9-20					
19	19	M22759 32-18					
20	20	M81381 7-22					

Wire Harness Description – Tray 2, Top Row, Column 2 (continued)

Front Connector: **MS24264R16B24PN**

Aft Connector: **MS24266R16B24SN (Female)**

Front Pin ID	Aft Pin ID	Wire Type	Defect Identified (Type: Severity: Location:				Comments
21	21	M22759 32/22					
22	22	M5086 1-22					
23	23	M81381 7-20					
24	24	M5086 1-20					

Harness Connectors In-Situ

Tray 2, Top Row, Column 3

Front: MS24264R14B15S9

Aft: MS24264R14B15S9

Wire Harness Description – Tray 2, Top Row, Column 3

Front Connector: **MS24264R14B15S9**

Aft Connector: **MS24264R14B15S9**

Front Pin ID	Aft Pin ID	Wire Type	Defects Identified (Type : Severity : Location)				Comments
1	1	M81044 9-18					
2	2	M81381 7-20					
3	3	M22759 32-18					
4	4	M5086 1–20					
5	5	M5086 1-22					
6	6	M5086 1-20					
7-15	7-15	Not Used					

Harness Connectors In-Situ

Tray 2, Top Row, Column 5

Front: MS24264R14B15P9

Aft: MS24264R14B15S9

Wire Harness Description – Tray 2, Top Row, Column 5

Front Connector: MS24264R14B15P9

Aft Connector: MS24264R14B15S9

Front Pin ID	Aft Pin ID	Wire Type	Defect Identified (Type : Severity : Location)				Comments
1	1	M81044 9-20					
2	2	M5086 1-22					
3	3	M22759 32-18					
4	4	M81381 7-22					
5	5	M81044 9-22					
6	6	M5086 1-22					
7-15	7-15	Not used					

Harness Connectors In-Situ

Tray 2, Top Row, Column 7

Front: MS24264R14T4PN

Aft: MS24264R14T4PN

Wire Harness Description – Tray 2, Top Row, Column 7

Front Connector: **MS24264R14T4PN**

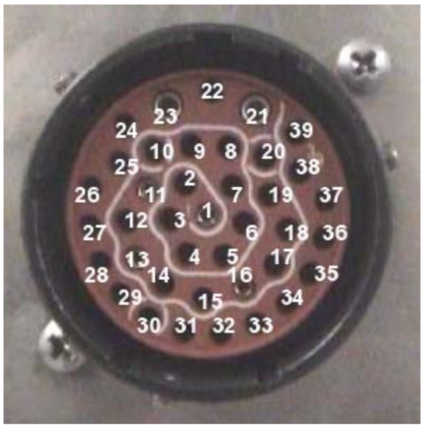
Aft Connector: **MS24264R14T4PN**

Front Pin ID	Aft Pin ID	Wire Type	Defect Identified (Type : Severity : Location)				Comments
1	1	M81381 7-20					
2	2	M22759 32-18					
3	3	M5086 1-20					
4	4	M81044 9-20					

Harness Connectors In-Situ

Tray 2, Top Row, Column 9

Front: MS24264R20B39S8



Aft: MS24264R20B39S8

Wire Harness Description – Tray 2, Top Row, Column 9

Front Connector: **MS24264R20B39S8**

Aft Connector: **MS24264R20B39S8**

Front Pin ID	Aft Pin ID	Wire Type	Defect Identified (Type : Severity : Location)				Comments
1	1	M81044 9-20					
2-10	2-10	Not used					
11	11	M81044 9-20					
12	12	Not used					
13	13	M81044 9-20					
14-15	14-15	Not Used					
16	16	M81381 7-20					
17-20	17-20	Not Used					
21	21	M81044 9-20					
22	22	Not Used					
23	23	M81044 9-22					
24-39	24-39	Not Used					

Harness Connectors In-Situ

Tray 2, Top Row, Column 13

Front: MS24264R16B24PN

Aft: MS24266R16B24SN

Wire Harness Description – Tray 2, Top Row, Column 13

Front Connector: **MS24264R16B24PN**

Aft Connector: **MS24266R16B24SN**

Front Pin ID	Aft Pin ID	Wire Type	Defect Identified (Type : Severity : Location)				Comments
1	1	M81044 9-20					
2	2	M81381 7-20					
3	3	M22759 32-20					
4	4	M5086 1-20					
5	5	M81381 7-20					
6	6	M22759 32-18					
7	7	M81044 9-18					
8	8	M81381 7-20					
9	9	M81381 7-20					
10	10	M22759 32-20					
11	11	M22759 32-20					
12	12	M81044 9-20					
13	13	M81044 9-18					
14	14	M5086 1-20					
15	15	M22759 32-18					
16	16	M81044 9-20					
17	17	M81381 7-20					
18	18	M81044 9-18					
19	19	M81381 7-20					

Wire Harness Description –Tray 2, Top Row, Column 13(continued)

Front Connector: **MS24264R16B24PN**

Aft Connector: **MS24266R16B24SN**

Front Pin ID	Aft Pin ID	Wire Type	Defect Identified (Type : Severity : Location)				Comments
20	20	M81044 9-18					
21	21	M22759 32-20					
22	22	M81044 9-20					
23	23	M81044 9-20					
24	24	M22759 32-20					

Harness Connectors In-Situ

Tray 2, Top Row, Column 15

Front: MS24264R10B5PN

Aft: MS24266R10B5PN

Wire Harness Description – Tray 2, Top Row, Column 15

Front Connector: **MS24264R10B5PN**

Aft Connector: **MS24266R10B5PN**

Front Pin ID	Aft Pin ID	Wire Type	Defect Identified (Type : Severity : Location)				Comments
1	1	M81044 9-20					
2	2	M22759 32-18					
3	3	M5086 1-22					
4	4	M81381 7-22					
5	5	Not Used					

Harness Connectors In-Situ

Tray 2, Top Row, Column 17

Front: MS24264R16B24SN

Aft: MS24264R16B24PN

Wire Harness Description – Tray 2, Top Row, Column 17

Front Connector: **MS24264R16B24SN**

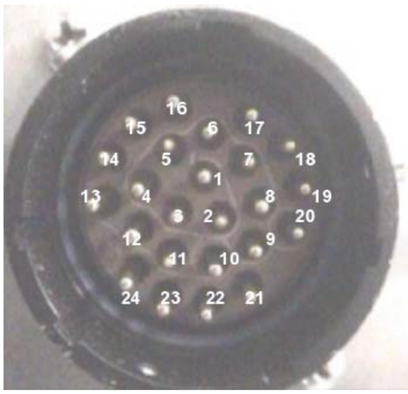
Aft Connector: **MS24264R16B24PN**

Front Pin ID	Aft Pin ID	Wire Type	Defect Identified (Type : Severity : Location)				Comments
1	1	M5086 1-20					
2	2	M81044 9-20					
3	3	M81381 7-22					
4	4	M81044 9-22					
5	5	M5086 1-20					
6	6	M81381 7-20					
7-24	7-24	Not Used					

Harness Connectors In-Situ

Tray 2, Top Row, Column 19

Front: MS24264R16B24PN



Aft: MS24266R16B24SN

Wire Harness Description – Tray 2, Top Row, Column 19

Front Connector: **MS24264R16B24PN**

Aft Connector: **MS24266R16B24SN**

Front Pin ID	Aft Pin ID	Wire Type	Defect Identified (Type : Severity : Location)				Comments
1	1	M5086 1-20					
2	2	M22759 32-22					
3	3	M81044 9-22					
4	4	M5086 1-20					
5	5	M22759 32-22					
6	6	M81381 7-22					
7	7	M81044 9-20					
8	8	M5086 1-22					
9	9	M81044 9-18					
10	10	M81381 7-20					
11	11	M22759 32-18					
12	12	M22759 32-20					
13	13	M5086 1-22					
14	14	M81044 9-22					
15	15	M81044 9-18					
16	16	M81381 7-22					
17	17	M5086 1-20					
18	18	M81044 9-18					
19	19	M81381 7-20					

Wire Harness Description – Tray 2, Top Row, Column 19 (continued)

Front Connector: **MS24264R16B24PN**

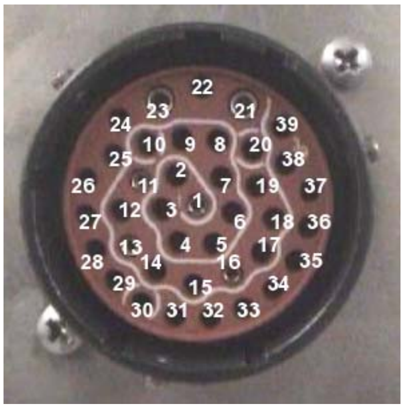
Aft Connector: **MS24266R16B24SN**

Front Pin ID	Aft Pin ID	Wire Type	Defect Identified (Type : Severity : Location)				Comments
20	20	M81044 9-22					
21	21	M81381 7-22					
22	22	M22759 32-22					
23	23	M81381 7-20					
24	24	M5086 1-22					

Harness Connectors In-Situ

Tray 2, Top Row, Column 21

Front: MS24264R20B39S8



Aft: MS24266R20B39P8

Wire Harness Description – Tray 2, Top Row, Column 21

Front Connector: **MS24264R20B39S8**

Aft Connector: **MS24266R20B39P8**

Front Pin ID	Aft Pin ID	Wire Type	Defect Identified (Type : Severity : Location)				Comments
1-5	1-5	Not Used					
6	6	M5086 1-20					
7-20	7-20	Not Used					
		Dummy Pin					
		Not Used					
21	21	M22759 32-22					
22	22	Not used					
23	23	M81381 7-20					
24-29	24-29	Not Used					
30	30	M81044 9-20					
31-33	31-33	Not Used					
34	34	M81044 9-20					
35-38	35-38	Not Used					
		Dummy Pin					
		Not Used					
39	39	M22759 32-18					

Harness Connectors In-Situ

Tray 3, Top Row, Column 2

Front: MS24264R16B24SN

Aft: MS24266R14B15SNX

Wire Harness Description – Tray 3, Top Row, Column 2

Front Connector: **MS24264R16B24SN**

Aft Connector: **MS24266R14B15SNX**

Front Pin ID	Aft Pin ID	Wire Type	Defect Identified (Type : Severity : Location)				Comments
1		Not used					
	1	W42A/8/1-20					
2	2	W42A/8/1-20					
3		Not Used					
	3	W42A/8/1-20					
4	4	W42/8/1-20					
5	5	W42A/8/1-20					
6	6	W42A/8/1-20					
7	7	W42A/8/1-22					
8	8	W42A/8/1-22					
9	9	W42A/8/1-20					
10	10	W42A/8/1-20					
11	11	W42A/8/1-22					
	12	W42A/8/1-20					
12		Not used					
	13-15	Not Used					
13-24		Not Used					

Harness Connectors In-Situ

Tray 3, Top Row, Column 4

Front: MS24264R12B12PN

Aft: MS24266R12B12SN

Wire Harness Description – Tray 3, Top Row, Column 4

Front Connector: **MS24264R12B12PN**

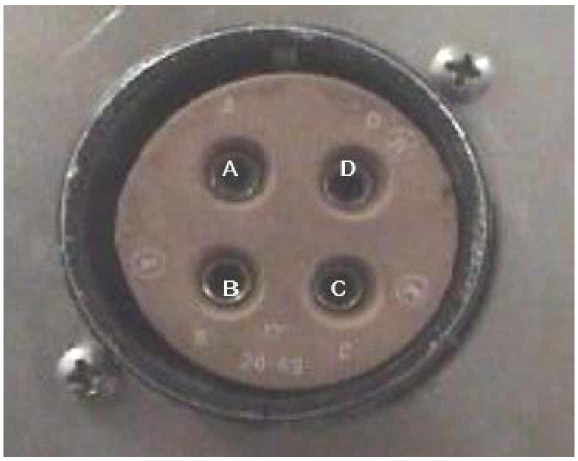
Aft Connector: **MS24266R12B12SN**

Front Pin ID	Aft Pin ID	Wire Type	Defect Identified (Type : Severity : Location)				Comments
1	1	W1213 RZ2421-20R					
2	2	W1213 RZ2422-20B					
3	3	W1213 RZ2424-20Y					
4	4	W51F/B/14/1-20					
5		Not Used					Twisted Shielded Pairs: (1,2,3)
	5	Dummy Socket					Front shield terminated by stripping
6	6	W51F/B/17/1-24					Aft shield termination unknown
7-12		Not Used					
	7	Dummy Socket					
	8	W51F/B/14/1-20					
	9-12	Dummy Socket					

Harness Connectors In-Situ

Tray 3, Top Row, Column 6

Front: 9229-20



Aft: MS24266R20B25S9

Wire Harness Description – Tray 3, Top Row, Column 6

Front Connector: **9229-20**

Aft Connector: **MS24266R20B25S 9**

Front Pin ID	Aft Pin ID	Wire Type	Defect Identified (Type : Severity : Location)				Comments
A	24	W51F/8/8/1-14					
B	20	W51F8/8/1-14					
C	16	W51F/8/8/11-14					
D		W51F/8/8/1-14					
	1-15	Not Used					
	17-19	Not Used					
	21-23	Not Used					
	25	Not Used					

Harness Connectors In-Situ

Tray 3, Top Row, Column 8

Front: MS24264R14T4PN

Aft: MS24266R18B8PN

Wire Harness Description – Tray 3, Top Row, Column 8

Front Connector: **MS24264R14T4PN**

Aft Connector: **MS24266R18B8PN**

Front Pin ID	Aft Pin ID	Wire Type	Defect Identified (Type : Severity : Location)				Comments
1	3	W1090-L4441					
2	4	W420/8/1-14					
3	7	W420/8/1-14					
4	8	W420/8/1-14					
	1-2	Dummy Pins					
	5-6	Dummy Pins					

Harness Connectors In-Situ

Tray 3, Top Row, Column 10

Front: MS24264R22B19P8

Aft: ZZL-R-17 24-3D-S06

Wire Harness Description – Tray 3, Top Row, Column 10

Front Connector: **MS24264R22B19P8**

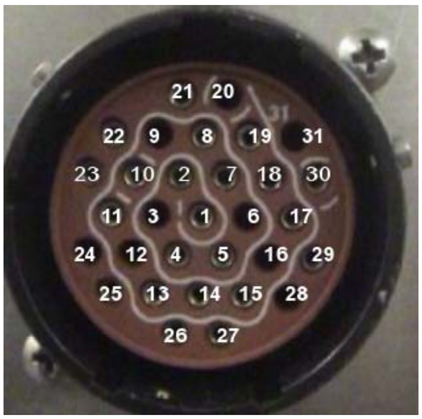
Aft Connector: **No Visible Number – 30 Sockets (ZZL-R-17 24-3D-S06)**

Front Pin ID	Aft Pin ID	Wire Type	Defect Identified (Type : Severity : Location)				Comments
1	5	W42A/8/1-20					
2	7	W42A/8/1-20					
3	8	W362-G236R					
4	9	W362-G236R					
5	10	W362-G239B					
6	11	W362-G239B					Front shield terminated by stripping
7	12	W42A/8/1-20					Twisted Shielded Pairs: (3,4)(5,6)(9,10)
8	13	W42A/8/1-20					Aft shield termination unknown
9	21	W362-D67R					Naturally Occurring Defect
10	22	W362-D67R					
11	24, 25	W362-D69R					
12	26	W362-D69R					
	6	W42/8/1-18					
	17	W42/8/1-18					
	1-4	Dummy Sockets					
	14-16	Dummy Sockets					
	18-20	Dummy Sockets					
	23	Dummy Sockets					
	27-30	Dummy Sockets					
13-19		Not Used					

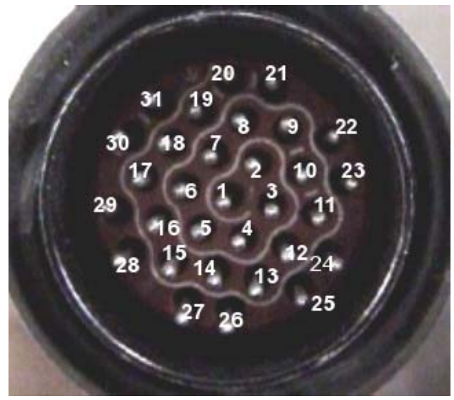
Harness Connectors In-Situ

Tray 3, Top Row, Column 12

Front: MS24264R18B31S8



Aft: MS24266R18B31P8



Wire Harness Description – Tray 3, Top Row, Column 12

Front Connector: **MS24264R18B31S8**

Aft Connector: **MS24266R18B31P8**

Front Pin ID	Aft Pin ID	Wire Type	Defect Identified (Type : Severity : Location)				Comments
1	1	*					
2	2	*					
3		Not Used					
	3	Dummy Pin					
4	4	*					
5	5	*					
6		Not Used					
	6	Dummy Pin					Twisted Shielded Pairs: (1,2)(4,5)(7,8)
7	7	*					(10,11)(13,14,15)(17,18,19)(21,22,23)
8	8	*					(25,26,27)(28,29)
9		Not Used					Front shield terminated by stripping
	9	Dummy Pin					Aft shield terminated to specified pins
10	10	*					
11	11	*					
12		Not Used					
	12	Dummy Pin					
13	13	*					
14	14	*					
15	15	*					
16		Not Used					

Wire Harness Description – Tray 3, Top Row, Column 12 (continued)

Front Connector: **MS24264R18B31S8**

Aft Connector: **MS24266R18B31P8**

Front Pin ID	Aft Pin ID	Wire Type	Defect Identified (Type : Severity : Location)				Comments
	16	Dummy Pin					
17	17	*					
18	18	*					
19	19	*					
20		Not Used					
	20	Dummy Pin					
21	21	*					
22	22	*					
23	23	*					
24		Not Used					
	24	Dummy Pin					
25	25	*					
26	26	*					
27	27	*					
28		Not Used					

Wire Harness Description – Tray 3, Top Row, Column 12 (continued)

Front Connector: **MS24264R18B31S8**

Aft Connector: **MS24266R18B31P8**

Front Pin ID	Aft Pin ID	Wire Type	Defect Identified (Type : Severity : Location)				Comments
	28	Dummy Pin					
29	29	*					
30	30	*					
31		Not Used					
	31	Dummy Pin					

Harness Connectors In-Situ

Tray 3, Top Row, Column 14

Front: MS24264R18B31S8

Aft: ZZL-R-17 24-3D-S06

Wire Harness Description – Tray 3, Top Row, Column 14

Front Connector: **MS24264R18B31S8**

Aft Connector: **ZZL-R-17 24-3D-S06**

Front Pin ID	Aft Pin ID	Wire Type	Defect Identified (Type : Severity : Location)				Comments
1	1	W42A/8/1-20					
2	2	W42A/8/1-20					
3		Not Used					
	3	W42A/8/1-28					Twisted Shielded Pairs: (4,5)(6,7)
4	4	No visible #-- red					Front shield terminated by stripping
5	5	No Visible #--blue					Aft (4,5) shield terminated to pin 19
6	6	No Visible #--Red					Aft (6,7) shield termination unknown
7	7	No Visible #--blue					
8	8	W42A/8/1-20					
9	9	W42A/8/1-20					
10	10	W42A/8/6-20-red					Twisted wires: (10,12,13,14,15,16)
11		Not Used					
	11	Dummy Pin					
12	12	No Visible #-blue					
13	13	No visible #--yellow					
14	14	No visible number—green					
15	15	No visible number—black					
16	16	No visible number-Purple					

Wire Harness Description – Tray 3, Top Row, Column 14 (continued)

Front Connector: **MS24264R18B31S8**

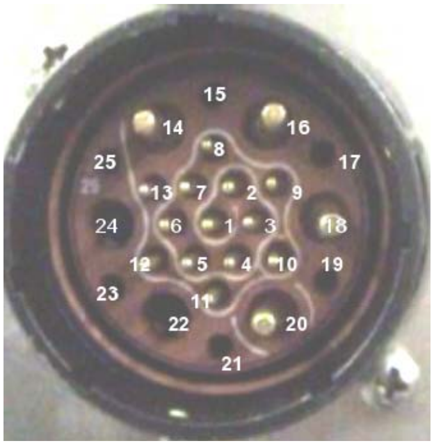
Aft Connector: **ZZL-R-17 24-3D-S06**

Front Pin ID	Aft Pin ID	Wire Type	Defect Identified (Type : Severity : Location)				Comments
17-31		Not Used					
	17	Dummy Pin					
	18	W42A/8/1-24					
	19						
	20-30	Dummy Pins					

Harness Connectors In-Situ

Tray 3, Top Row, Column 16

Front: MS24264R20B25PN



Aft: MS24266R22B32PN

Wire Harness Description – Tray 3, Top Row, Column 16

Front Connector: **MS24264R20B25PN**

Aft Connector: **MS24266R22B32PN**

Front Pin ID	Aft Pin ID	Wire Type	Defect Identified (Type : Severity : Location)				Comments
1	7	W48 VIII 1-20					
2	15	W48 VIII 1-20					
3	3	W48 VIII 1-20					
4	18	W48 VIII 1-20					
5	19	W48 VIII 1-20					
6	20	W48 VIII 1-20					
7	23	W48 VIII 1-20					
8	25	W48 VIII 1-20					
9	26	W42D/8/1-20					
10	27	W42D/8/1-20					
11	28	W42D/8/1-20					
12	29	W48A/01 8/1-20					
13	31	W48 VIII 1-20					
16	4	W42D/3/1-14					
18	6	W42D/3/1-14					
20	30	D/W48/VIII/1/16					
14		Dummy Pin					
15		Not Used					
17		Not Used					

Wire Harness Description – Tray 3, Top Row, Column 16 (continued)

Front Connector: **MS24264R20B25PN**

Aft Connector: **MS24266R22B32PN**

Front Pin ID	Aft Pin ID	Wire Type	Defect Identified (Type : Severity : Location)				Comments
19		Not Used					
21-25		Not Used					
	1-2	Dummy Pin					
	5	Dummy Pin					
	8-14	Dummy Pin					
	16-17	Dummy Pin					
	21-22	Dummy Pin					
	24	Dummy Pin					
	32	Dummy Pin					

Harness Connectors In-Situ

Tray 3, Top Row, Column 18

Front: MS24264R16B24PN

Aft: 704801

Wire Harness Description – Tray 3, Top Row, Column 18

Front Connector: **MS24264R16B24PN**

Aft Connector: **704801**

Front Pin ID	Aft Pin ID	Wire Type	Defect Identified (Type : Severity : Location)				Comments
1	1	W42A/1/3-22					
2	2	No Visible #--blue					
3	3	No Visible #--yellow					
4-5		Not Used					
	4-5	Dummy Sockets					
6	6	W42/1/3-20					
7	7	No Visible #--blue					
8	8	No Visible #--yellow					Twisted wires: (1,2,3)(6,7,8)
9-24		Not Used					
	9-12	Dummy Sockets					

Harness Connectors In-Situ

Tray 3, Top Row, Column 20

Front: MS24264R22B55P7

Aft: MS24266R22B55S7

Wire Harness Description –Tray 3, Top Row, Column 20

Front Connector: **MS24264R22B55P7**

Aft Connector: **MS24266R22B55S7**

Front Pin ID	Aft Pin ID	Wire Type	Defect Identified (Type : Severity : Location)				Comments
1	1	W247-R246					
2	2	W42A/13/2-24					
3	3	W42A/13/2-24					
4	4	W247-R264					
5	5	W247-RZ62-24					
6	6	W247-RZ60-24					
7	7	W247-RZ283					
8	8	W247-RZ65					
9	9	W42/A/13/2-24					Twisted shielded pairs: (2,3)(9,10)
10	10	W42/A/13/2-24					(11,25)(13,14)(15,16)(17,18)
11	11	W42/A/13/2-24					(26,27)(32,33)
12	12	W247-RZ61-24					
13	13	W42A/13/2-24					Front shield terminated by stripping
14	14	W42A/13/2-24					Aft shield termination unknown
15	15	W42A/13/2-24					
16	16	W42A/13/2-24					
17	17	W42A/13/2-24					
18	18	W42A/13/2-24					
19	19	W247-RZ63-24					
20	20	Not Used					

Wire Harness Description – Tray 3, Top Row, Column 20 (continued)

Front Connector: **MS24264R22B55P7**

Aft Connector: **MS24266R22B55S7**

Front Pin ID	Aft Pin ID	Wire Type	Defect Identified (Type : Severity : Location)				Comments
21	21	W247 R55-24					
22	22	Not Used					
23	23	W247-RZ58-24					
24	24	W247-RZ59-24					
25	25	W42A/13/2-24					
26	26	W42A/13/2-24					
27	27	W42A/13/2-24					
28	28	W247-RZ60-24					
29-31	29-31	Not Used					
32	32	W42A/13/2-24					
33	33	W42A/13/2-24					
34		W247-RZ67-24					
35	35	W247-RZ1-24					
36	36	W247-RZ3-24					
37	37	W247-RZ53-24					
38-39	38-39	Not Used					
40	40	W247-RZ51-24					
41-43	41-43	Not Used					

Wire Harness Description – Tray 3, Top Row, Column 20 (continued)

Front Connector: **MS24264R22B55P7**

Aft Connector: **MS24266R22B55S7**

Front Pin ID	Aft Pin ID	Wire Type	Defect Identified (Type : Severity : Location)				Comments
45	45	W247-RZ57-24					
46-48	46-48	Not Used					
49	49	W42A/8/1-22					
50	50	Not Used					
51	51	W247-RZ63-24					
52-53	52-53	Not Used					
54	54	W247-RZ5-24					
55	55	W247-RZ50-24					
	44	W247-RZ281-24					
44		Not Used					
	34	Not Used					

Harness Connectors In-Situ

Tray 4, Top Row, Column 3

Front: MS24264R12B12PN

Aft: 704701

Wire Harness Description – Tray 4, Top Row, Column 3

Front Connector: **MS2426R12B12PN**

Aft Connector: **704701**

Front Pin ID	Aft Pin ID	Wire Type	Defect Identified (Type : Severity : Location)				Comments
1	1	W42A/8/1-20					
2	2	W42A/8/1-20					
3	3	W42A/8/1-20					
4	4	W42A/8/1-20					
5	5	W42A/8/1-20					
6	6	W42A/8/1-20					
7	7	W42A/8/1-20					
8	8	W42A/8/1-20					
9	9	W42A/8/1-20					
10	10	W42A/8/1-20					
11	11	W42A/8/1-20					
12	12	W42A/8/1-20					

Harness Connectors In-Situ

Tray 4, Top Row, Column 5

Front: MS24264R22B55P7

Aft: No Visible Number-55 socket

Wire Harness Description – Tray 4, Top Row, Column 5

Front Connector: **MS24264R22B55P7**

Aft Connector: **No Visible Number—55 Sockets**

Front Pin ID	Aft Pin ID	Wire Type	Defect Identified (Type : Severity : Location)				Comments
1-21		Not Used					
22	k	*					
23	j	*					
24	i	*					
25-26		Not Used					
27	f						
28		Not Used					
29	d	*					
30	c	*					
31	a	*					
32-33		Not Used					
34	Y	*					
35	m	*					
36	X	*					
37-38		Not Used					
39	T	*					
40-43		Not Used					
44	M	*					
45		Not Used					

Wire Harness Description – Tray 4, Top Row, Column 5 (continued)

Front Connector: **MS24264R22B55P7**
Aft Connector: **No Visible Number—55 Sockets**

Front Pin ID	Aft Pin ID	Wire Type	Defect Identified (Type : Severity : Location)				Comments
46	K	*					
47	J	*					
48	H	*					
49	G	*					
50	F	*					
51	E	*					
52	D	*					
53		Not Used					
54	B	*					
55	A	*					
	n	Not Used					
	s-t	Not Used					
	v	Not Used					
	AA	Not Used					
	DD	Not Used					
	C	*					
	L	*					
	N-W	*					
	Z	*					*No Visible Numbers on Wires

Wire Harness Description – Tray 4, Top Row, Column 5 (continued)

Front Connector: **MS24264R22B55P7**

Aft Connector: **No Visible Number—55 Sockets**

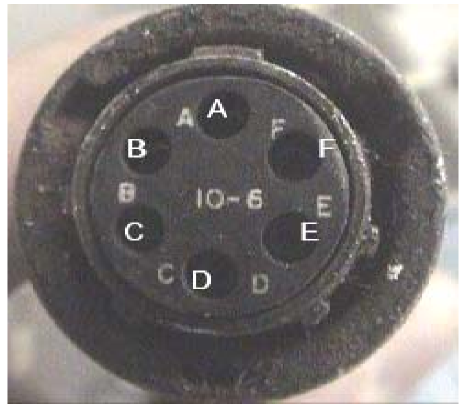
Front Pin ID	Aft Pin ID	Wire Type	Defect Identified (Type : Severity : Location)				Comments
	b	*					
	e	*					
	g-h	*					
	l	*					
	o-r	*					
	u	*					
	w-z	*					
	BB-CC	*					
	EE-HH	*					
							*No Visible Numbers on Wires

Harness Connectors In-Situ

Tray 4, Top Row, Column 7

Front: MS24264R14T4PN

Aft: No Visible Number- 6 socket



Wire Harness Description – Tray 4, Top Row, Column 7

Front Connector: **MS24264R14T4PN**

Aft Connector: **No Number Visible—6 Socket**

Front Pin ID	Aft Pin ID	Wire Type	Defect Identified (Type : Severity : Location)				Comments (Pedigree)
1		Not Used					
2	B	7616964A24					
3		Dummy Pin					
4	D	7616964A24					
	A	No Number Visible					
	C	2D153C24					
	E	Dummy Socket					
	F	Dummy Socket					

Harness Connectors In-Situ

Tray 4, Top Row, Column 9

Front: MS24264R10B5SN

Aft: No Visible Number- 10 socket

Wire Harness Description – Tray 4, Top Row, Column 9

Front Connector: MS24264R10B5SN

Aft Connector: No Visible Number—10 Socket

Front Pin ID	Aft Pin ID	Wire Type	Defect Identified (Type : Severity : Location)				Comments
1	A	No Visible Number					
3	C	No Visible Number					
	B	M22759 8-20-9					
	D	M22759 8-20-9					
	E	Dummy Socket					
	F	M22759 8-20-9					
	G	M22759 8-20-9					Twisted shielded pair: (1,3)
	H	Dummy Socket					Front shield terminated by stripping
	J	M22759 8-20-9					Aft shield termination unknown
	K	M22759 8-20-9					
2		Not Used					
4-5		Not Used					

Harness Connectors In-Situ

Tray 4, Top Row, Column 11

Front: MS24264R14T4PN

Aft: MS24264R14T4PN

Wire Harness Description – Tray 4, Top Row, Column 11

Front Connector: **MS24264R14T4PN**

Aft Connector: **MS24264R14T4PN**

Front Pin ID	Aft Pin ID	Wire Type	Defect Identified (Type : Severity : Location)				Comments
1	1	*					
2	2	*					
3	3	*					
4	4	*					
							Twisted pairs: (1,2)(3,4)

Harness Connectors In-Situ

Tray 4, Top Row, Column 13

Front: MS24264R14T7P6

Aft: No Visible Number- 15 socket

Wire Harness Description – Tray 4, Top Row, Column 13

Front Connector: MS24264R14T7P6

Aft Connector: No Visible Number—15 Sockets

Front Pin ID	Aft Pin ID	Wire Type	Defect Identified (Type : Severity : Location)				Comments
1	P	MS2519C-3-18					
2	B	DAC 7616 964-B24					
3	J	DAC 7616 964-B24					
4	M	DAC 7616 964-B24					
5	H	No visible numbers					
6	G	No visible numbers					
7	A	DAC 7616 964-B24					Twisted shielded pair: (5,6)
	C-F	Dummy Socket					Front shield terminated by stripping
	L	Dummy Socket					Aft shield termination unknown
	N	Dummy Socket					
	R	Dummy Socket					
	E	No Visible Number					
	K	No Visible Number					

Harness Connectors In-Situ

Tray 4, Top Row, Column 15

Front: MS24264R10B5PN

Aft: MS24266R16B24SN

Wire Harness Description –Tray 4, Top Row, Column 15

Front Connector: M24264R10B5PN

Aft Connector: MS24266R16B24SN

Front Pin ID	Aft Pin ID	Wire Type	Defect Identified (Type : Severity : Location)				Comments
1	2	No Visible Numbers					
2	1	No Visible Numbers					
3	3	No Visible Numbers					
4	4	No Visible Numbers					Twisted shielded pairs: (1,2)(3,4)
5		Not Used					Front shield terminated by stripping
	5-24	Not Used					Aft shield termination unknown

Harness Connectors In-Situ

Tray 4, Top Row, Column 17

Front: MS24264R22B55S8

Aft: MS24266R22B55P8

Wire Harness Description – Tray 4, Top Row, Column 17

Front Connector: MS24264R22B55S8

Aft Connector: MS24266R22B55P8

Front Pin ID	Aft Pin ID	Wire Type	Defect Identified (Type : Severity : Location)				Comments
1	1	MS25190-B20					
2	2	MS25190-B20					
3	3	MS25190-B20					
4	4	7616964-B24					
5	5	MS25190-B20					
6	6	MS25190-B20					
7	7	MS25190-B20					
8	8	MS25190-B20					
9	9	7616964-B24					
10	10	7616964-B24					
11	11	7616964-B24					
12	12	7616964-B24					
13	13	7616964-B24					
14-55	14-55	Not Used					

Harness Connectors In-Situ

Tray 4, Top Row, Column 19

Front: MS24264R14T7P6

Aft: MS24264R14T7S6

Wire Harness Description – Tray 4, Top Row, Column 19

Front Connector: MS24264R14T7P6

Aft Connector: MS24264R14T7S6

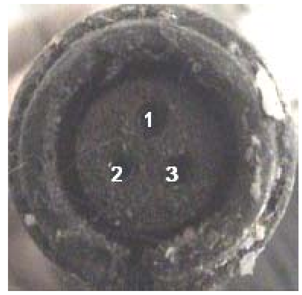
Front Pin ID	Aft Pin ID	Wire Type	Defect Identified (Type : Severity : Location)				Comments
1	1	No Number Visible—red					
2	2	No Number Visible—blue					
3	3	MS25190-B20					
4	4	RZ208124-green					
5	5	No Number Visible—blue					
6	6	No Number Visible—red					
7	7	Not Used					
							Twisted pairs: (1,2)(5,6)

Harness Connectors In-Situ

Tray 4, Top Row, Column 21

Front: MS24264R10B5PN

Aft: No Visible Number- 3 sockets



Wire Harness Description – Tray 4, Top Row, Column 21

Front Connector: MS24264R10B5PN

Aft Connector: No Number Visible—3 sockets

Front Pin ID	Aft Pin ID	Wire Type	Defect Identified (Type : Severity : Location)				Comments
1	1	2D304E24					
	2	2D306A24N					
	3	Dummy socket					
2-5		Not Used					

Annex E
Aircraft Wire Systems Defect Fabrication Procedures

This annex provides a description of each of the procedures used to fabricate the wire defects used in the test bed. This includes defect type, tools used, step-by-step text and illustrative photographs, and photographs of the resulting defect.

Aircraft Wire System Test-Bed Defects Fabrication

Harnesses used in the test bed enclosure will have one or more defects of the type described below. The defect descriptor found in Table 2 of the report corresponds to the specifications for each defect fabrication. The goal of these procedures was to make the fabrication process repeatable with little complexity.

DT-1: Insulation Abrasion

Tools: Dremel #380-6, Router Bit, Safety Glasses
Specification: Location on Wire; Radial Percent of Insulation Removed; Linear and Angular Extent

The following procedure describes the methods and tools used to fabricate abrasions into the wire used in the Test-Bed. Abrasions are made with a custom-milling fixture shown in Figure DT1-1 (Dremel Moto-Tool Model # 380-6, Variable Speed).

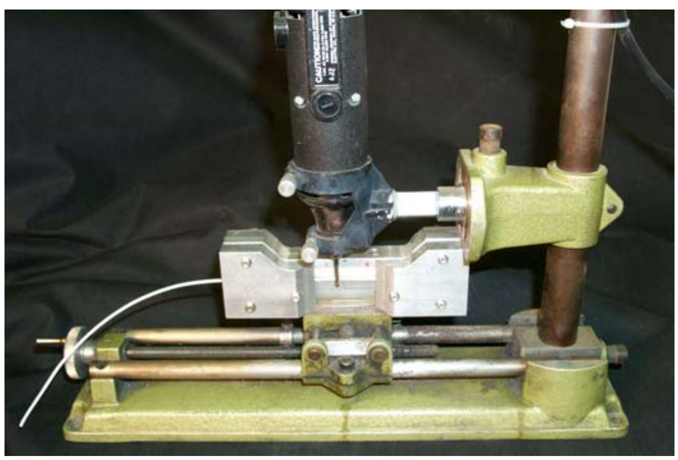


Figure DT1–1. Dremel Tool Mounted in Custom Mill

To achieve reproducibility, the same router bit shall be used in all abrasions put into the Test-Bed wiring (Dremel part number 9903, tungsten carbide bit, shown in Figure DT1-2). The Dremel Tool # 380-6 shall be operated at 28,000 RPM for all work. Because of varying dimensions in the insulations of different wire types used in the test bed, there will be differing amounts of feed used on each wire clamped in the mill. Figure DT1-2 shows two views of a wire clamped in the Dremel Mill.

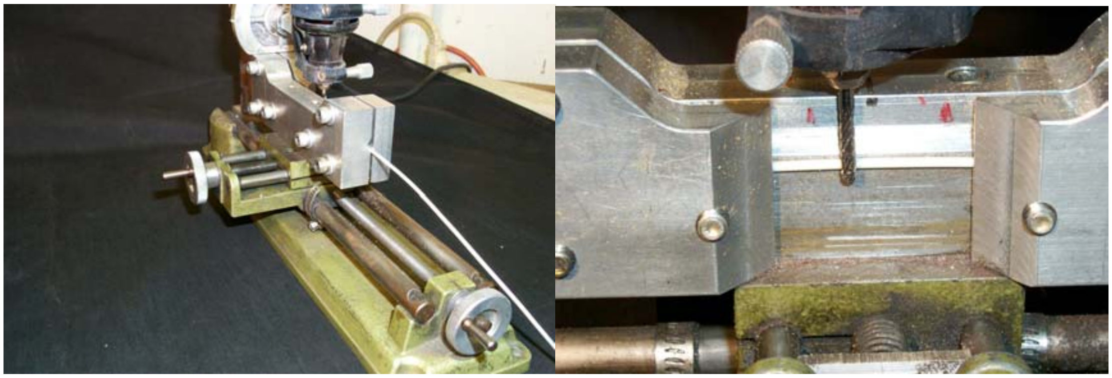


Figure DT1-2. Showing Two Views of a Wire Clamped in Abrasion Test Fixture

After the wire is clamped into the vise on the mill, the carbide cutter must then be located to within a few mils of the wire insulation. The technique of using a piece of paper (approximately 2 mils thick) between the bit and the insulation will be used. With one hand cranking the X-axis dial and the other hand sliding a small piece of paper between the bit and insulation, move the vise until the paper is just able to be removed from between the bit and wire without tearing (tool is not energized at this time). This technique is shown in Figure DT1-3.

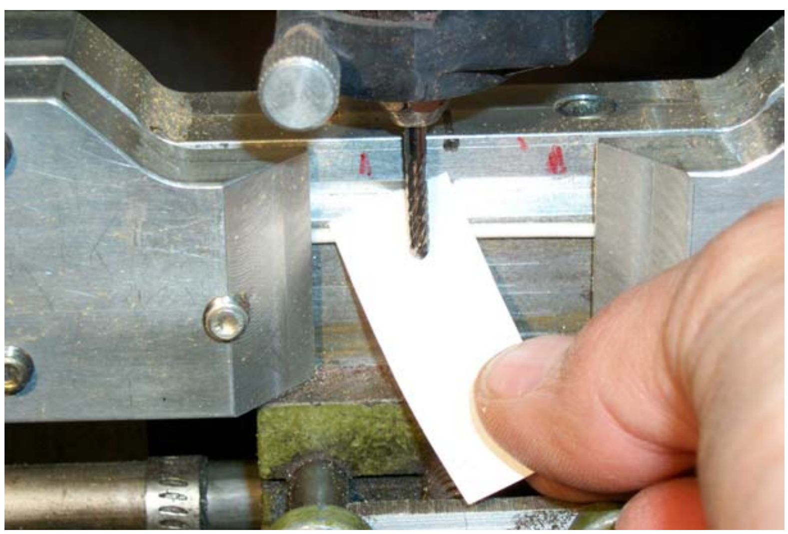


Figure DT1-3. Wire-to-Bit Spacing Adjustment Using Small Piece of Paper

Before energizing the tool, make sure that the Y-axis feed dial is fully counter-clockwise and travel is completed by the stop. Because of the rotation of the tool, all feeds for the lateral abrasions shall be done with one pass. Energize the Dremel and crank in on the X-axis dial to the desired depth. Each cut will be specific to the type of wire and type of cut required. The X-axis dial is marked with .0005” increments. Adjust the Y-axis stop to the specified abrasion length. Crank the Y-axis dial clockwise until the stop is encountered. Turn off Dremel tool and remove the wire from the vise. Two examples of wire abrasions are shown in Figures DT1-4 and –5.

Figure DT1-4. Partial Wire Insulation Abrasion

Figure DT1-5. Full Wire Insulation Abrasion Exposing Conductor

DT-2: Insulation Breach

Tools: Stanley 10-099 knife, Stanley 11-921 blade, 25 blade feeler gauge set, measurement calibers, Fixture #1, Allen Screw Driver, Safety Glasses

Specification: Location on Wire; 360° Insulation Removed; Linear Extent

Figure DT2-1. Stanley Knife and Blade

Figure DT2-2. Feeler Gauge Set

The following procedure describes the methods and tools used to fabricate three different incisions into the wire used in the test bed. The three different incisions will be referred to as the straight cut, the lateral breach, and partial insulation removal.

Straight Cut and Circumferential Lateral Breach

Measure the overall wire insulation diameter, splice off the insulation (at the end of a sample wire), and measure the conductor diameter. Subtract the conductor diameter from the insulation diameter. Divide this difference by two, resulting in the insulation radial thickness. Stack the proper amount of feeler gauges on a flat surface to equal the conductor diameter and radius of insulation thickness. Figure DT2-3 illustrates this geometry. Figure DT2-4 shows the cutting fixture (#1) and feeler gauges.

Figure DT2-3. Drawing of Breach Defect Cutting Geometry

Figure DT2-4. Breach Defect Cutting Fixture and Feeler-Gauges

Secure feeler gauges to work surface and lay test wire parallel to the edge of the gauges. Using the Stanley knife press down on the wire insulation until the blade contacts with the top surface of the feeler gauge stack and not going below the top surface of gauges. Figures DT2-5 and DT2-6 show the wire positioned in the cutting fixture and the resulting straight cut. Rotate the wire 90 to 180° and cut again. Repeat the process until a complete 360° circumferential cut through the insulation is achieved. To fabricate a circumferential lateral breach, produce two similar cuts at the desire separation length (e.g., 1 inch away). Make a lateral cut along the separation length, down to the feeler gauge, separate insulation halves, and remove. Figure DT2-7 shows a circumferential lateral breach.

Figure DT2-5. Wire Positioned in Cutting Fixture

Figure DT2-6. Straight Cut Result

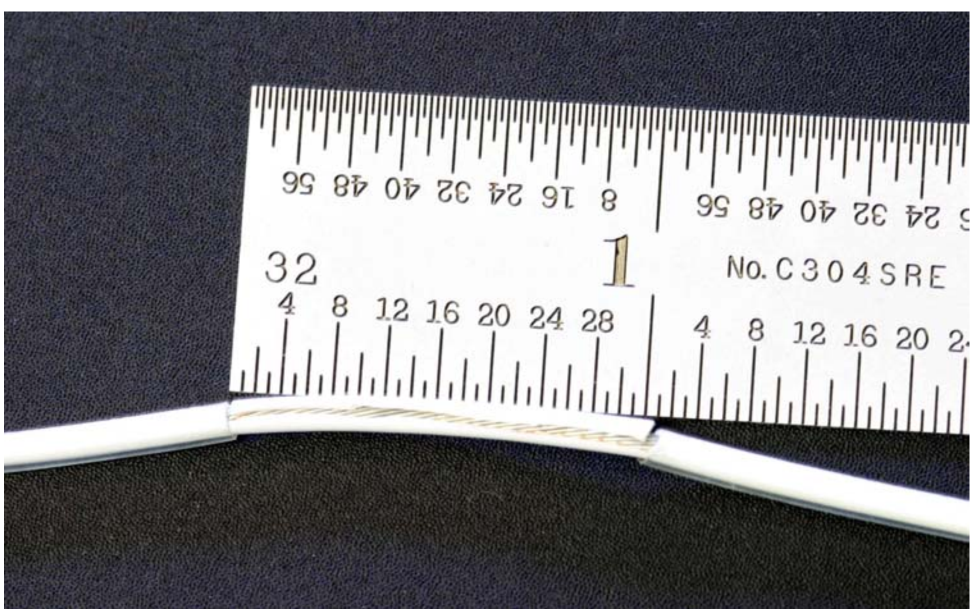
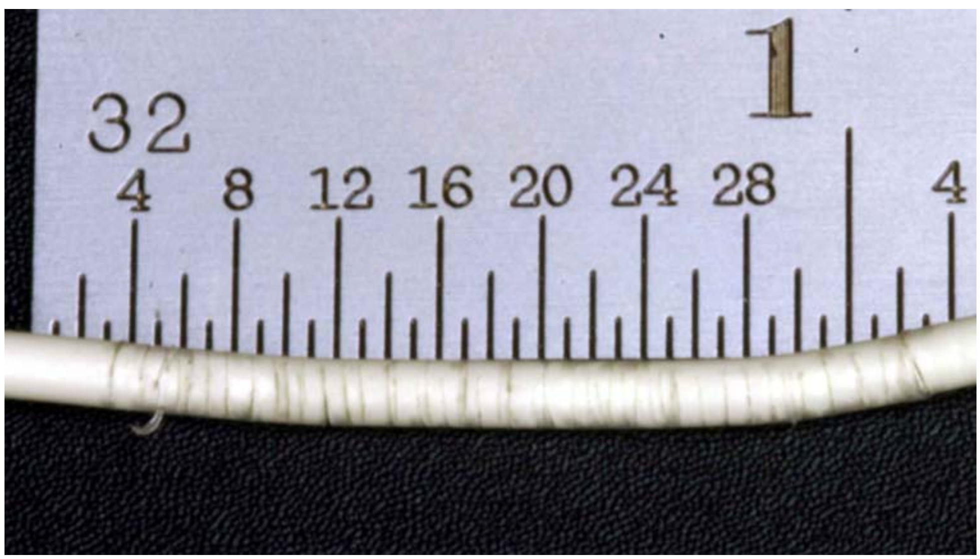


Figure DT2-7. Circumferential Lateral Breach

DT-3: Cracked Insulation

Tools: Same as specified in DT-2
Specification: Linear Extent; Percent into Insulation Radius; Density (cuts per inch)

The following procedure will describe a method used to fabricate cracked insulation on wires placed in the test bed. The method introduces a specified number of cracks per inch of wire (density) using the straight knife cut procedure described above in DT-2: Insulation Breach. Determine the proper height of feeler gauge stack by using the measuring steps described in DT2. For cuts that do not go all of the way to the conductor, calculate the additional amount of feeler gauge height by multiplying the percent of remaining insulation desired by the insulation thickness. Figure DT2-1 shows the setup for producing a single cut into the insulation. Figure DT3-1 shows the resulting defect after using this procedure.



DT3-1. Simulated Cracked Insulation Defect from Straight Knife Cuts

DT-4: Conductor Strand Breaks

Tools: Same as tools used in DT-2
Specification: Location on Wire; Percent of Conductor Strands Severed

The following procedure will describe the method used to fabricate wire conductor partial strand breakage. Using the procedure described for mounting the wire into the cutting fixture described in section DT-2, secure the specimen wire and feeler gauges on the cutting fixture. Using the Stanley knife, cut into insulation until side of blade is flush with feeler gauges. Make a 360^0 cut sufficient to expose conductor strands. Remove the wire from the fixture and using the knife select the particular strand. Using a smaller knife, sever the strand. Repeat the procedure until the specified number of strands is severed. After cutting the individual strands, bend each strand backwards (180°), so no contact is made with other strand cuts. Apply heat shrink tubing over defect to hold strands in place and to isolate severed strands. Figure DT4 – 1 shows the wire mounted in the fixture and strand selection and Figure DT4-2 shows the strand folded back.

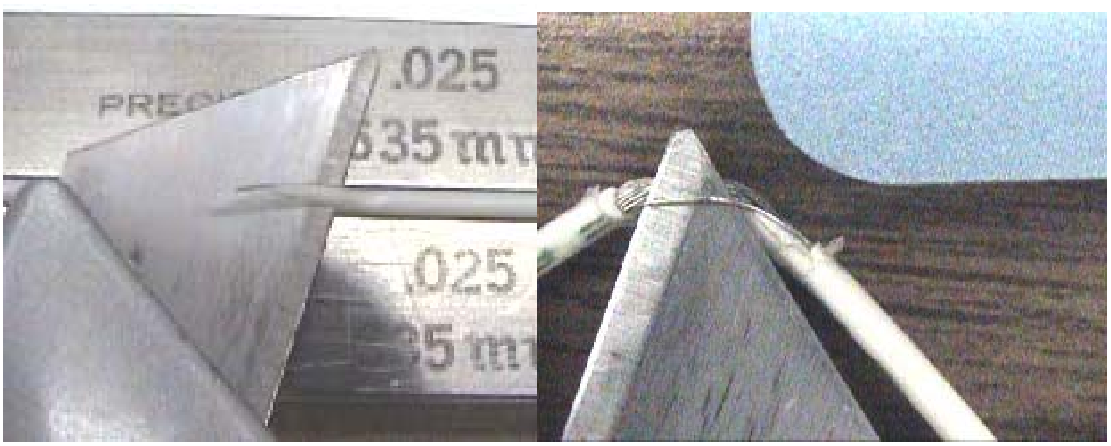


Figure DT4-1. Two Steps Required for a Partial Conductor Strand Cut

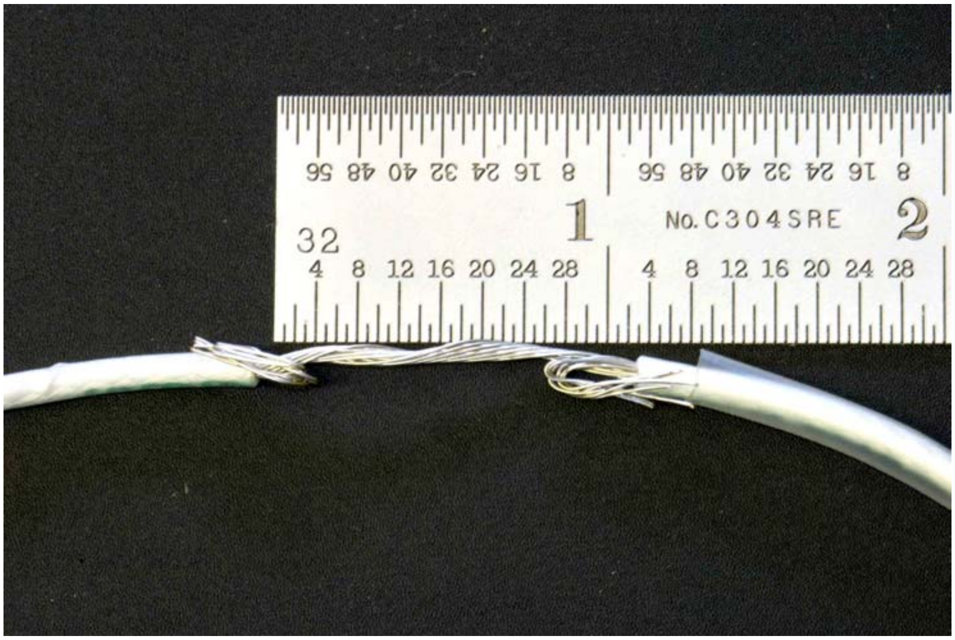
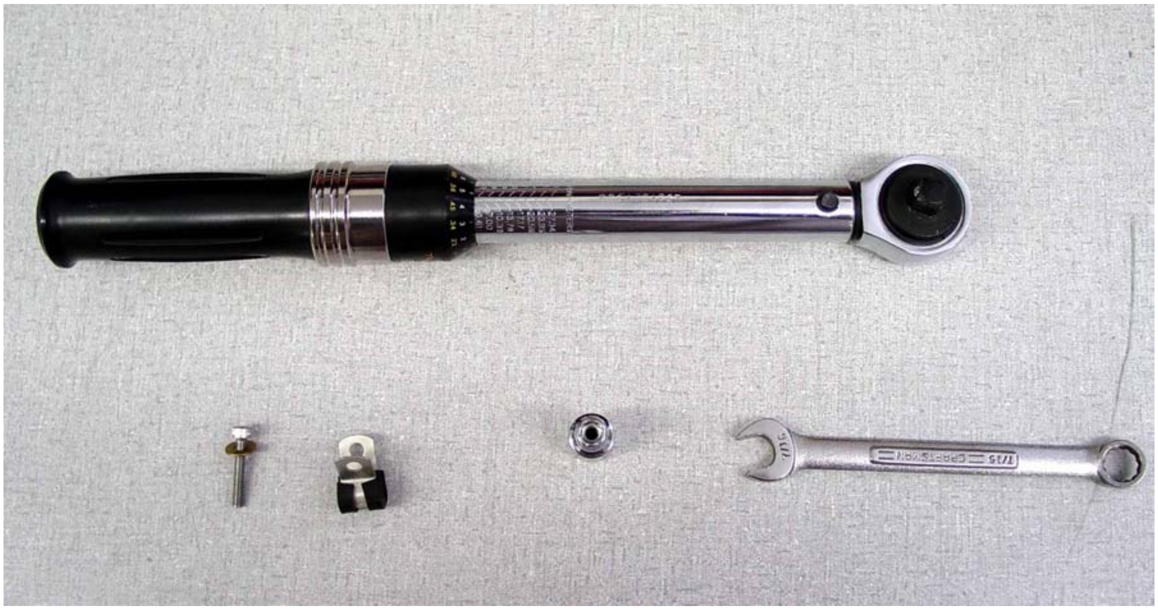


Figure DT4-2. Result of Conductor Strand Cut and Fold-Back

DT-5: Over-Pressured Clamps

Tools: Harness Clamp and Nut and Bolt, Socket and Torque Wrench, Ratchet, Safety Glasses
Specification: Location; Clamp Size, Torque Value

The following procedure describes the two methods used to over-pressure harness clamps. Figure DT5-1 shows the tools that are needed to produce an over-pressured clamp. Using a clamp that is undersized, remove any cushion/padding from the clamp and secure the clamp around the harness at the specified location. The location may correspond to a ribbed structure element of the simulated aircraft fuselage segment location within the enclosure. Using the socket wrench and an appropriately sized ratchet, compress the clamp around harness to a normal (~10 inch-lb) degree of tightness. Next use the torque wrench to the specified value of clamp tightness or compression (units of inch-lb). Another variation of this defect type is to allow one to three wires to be pinched by the hardware section of clamp. Both of these over-pressured clamp defects are shown in Figure DT5-2.



DT5-1. Tools Needed for DT5

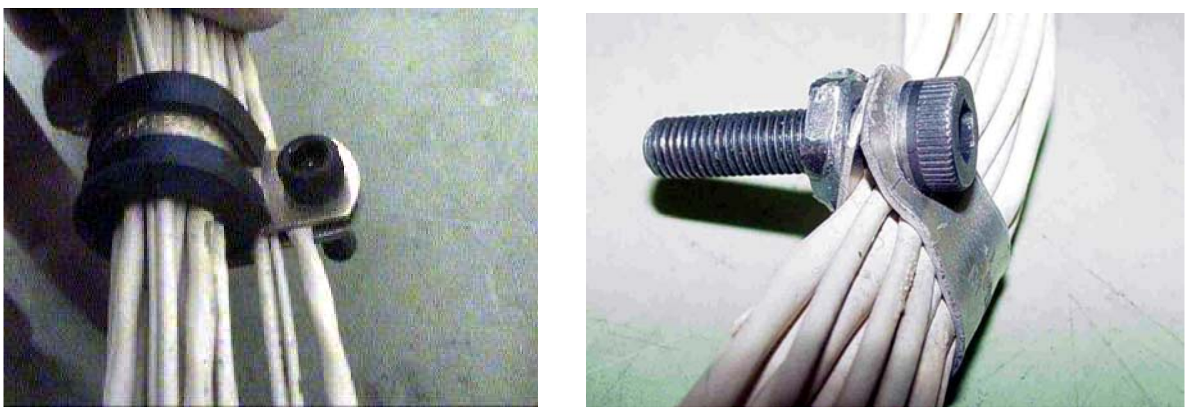


Figure DT5-2. Two Types of Over-Pressured Clamp Defects

Another clamp related defect is due to worn-away clamp insulation and the action (vibration) of the exposed metallic portion of the clamp rubbing against the wire insulation. This clamp-related defect type can be fabricated by using the procedure described in DT-1 to chafe-off insulation from one or more wires, and a clamp without an insulation barrier is placed over the chafed wire(s). However, this defect type is similar electrically to a short, or partial short, for a particular wire and is addressed in defect type DT-10 (short wire defect).

DT-6: Bend Radius

Tools: Plastic Tie-Bands, Tie-Band Tool
Specification: Location; Bend Diameter

The following procedure will describe the method used to introduce excessive bending radius of harnesses. Ensure that the specimen harness has sufficient length so that when installed into the test bed the connectors are capable of spanning the enclosure length. Bend the harness to a specified radius in multiples of harness diameter. Apply tie band. Repeat the process to orient the harness on the intended path within the enclosure. Figure DT6-1 shows a zero bend-radius defect with two tie bands securing the bends in place and a wire with harness diameter separation of about two diameters.

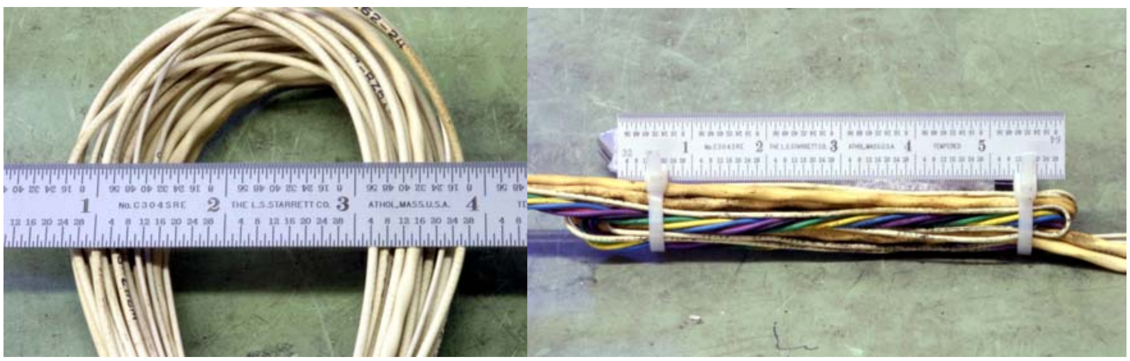
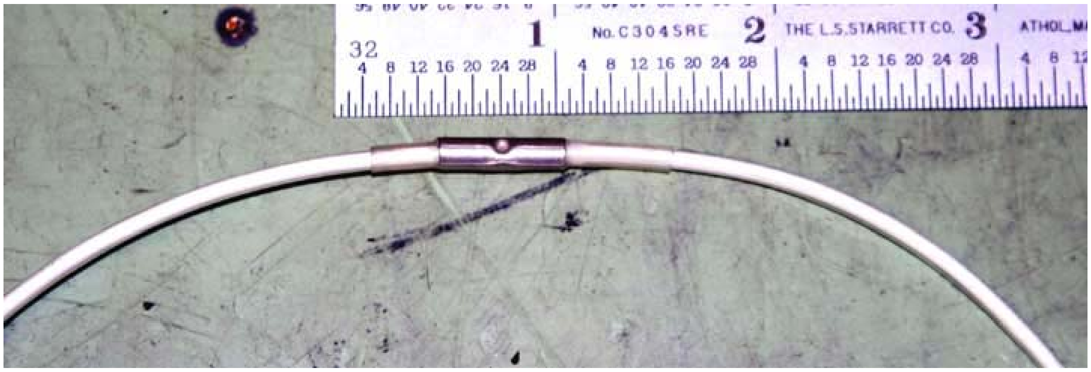


Figure DT6-1. Illustration of Harness Diameter Separation and Applied Tie-Band

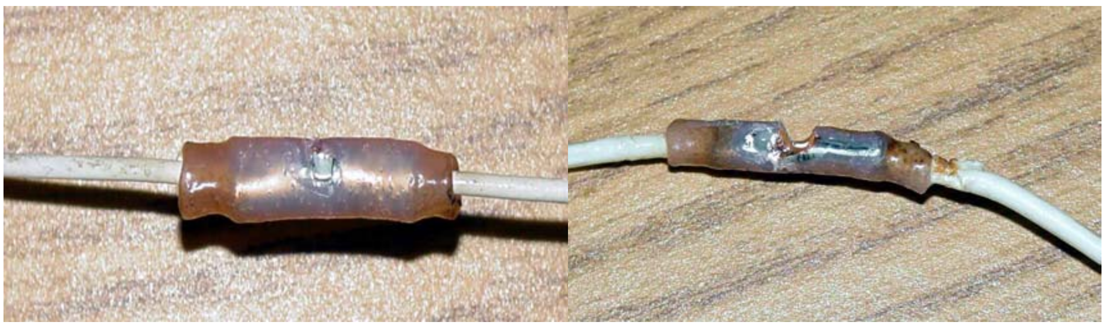
DT-7: Faulty Splice

Tools: Butt Splice Joint, Crimp Tool, Heat Shrink Tubing, Heat Gun, Electrical Tape
Specification: Location on Wire; Severity Type Details (see method description below)

The following procedure will describe three methods used to introduce faulted wire splices. The first method (type I) inserts each end of the wire to be joined into a butt joint but *with no* crimping and *with* heat applied to heat-shrink tubing that is placed about it. This defect is shown in Figure DT7-1. The second method (type II) is a crimped but exposed splice. This defect is shown in the left photograph of Figure DT7-2. The third method (type III) is a crimped splice but excessively over heated. This defect is shown in the right photograph of Figure DT7-2. This type three defect utilizes the charred insulation procedure, exposed for ~ 1 to 1.5 minutes, described in section DT-8 below.



DT7-1. Example of Type I Un-Crimped but Heated Faulted Splice



DT7-2. Type II (Left) and Type III (Right) Faulted Splices

<u>DT-8: Charred Insulation</u>

Tools: Heat Gun Wire-Mounting Fixture, Adjustable Wrench, Allen Driver, Thermocouple, Digital Thermometer, Safety Glasses, Thermal Protection Gloves
Specification: Location; Linear Extent; Exposure Duration

The following procedure describes the method used to fabricate charred wire specimens. Adjust the height of the heat gun wire-mounting fixture so that the wire holder is approximately 1-inch above the heat gun nozzle. The fixture is shown in Figure DT8-1. Turn on the heat gun until the thermometer indicates 500°F. Turn off the heat gun, and quickly place wire specimen on fixture. Turn on the heat gun and expose wire for specified duration. Record exposure time and indicated temperature. Do not allow heat gun to cool down until all desired wires are burned. Figure DT8-2 shows the resulting defects of varying burn severities.

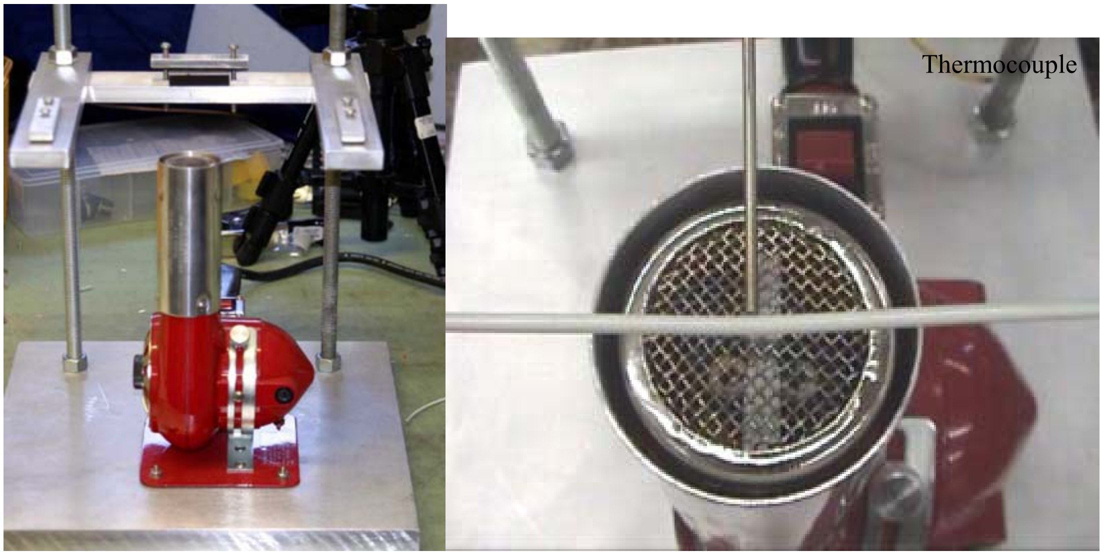
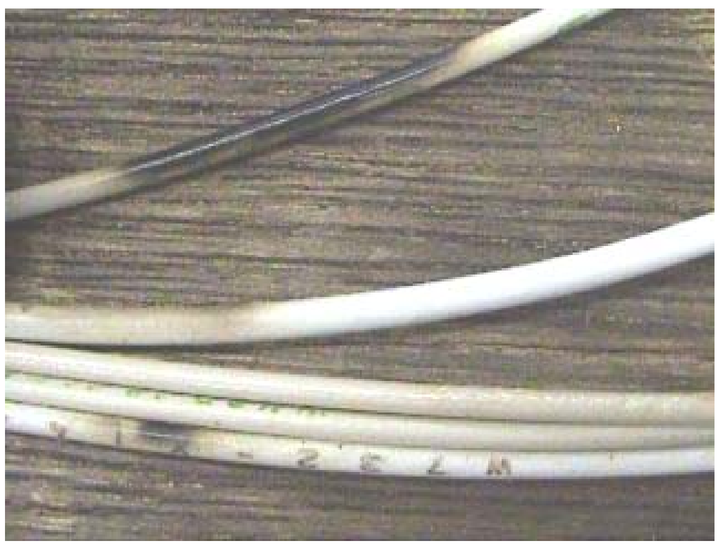


Figure DT8-1. Heat Gun and Wire Mounting Fixture with Close-up View of Wire Positioned Over Heat Gun Nozzle



DT8-2. Resulting Severities of Burnt Wires

DT-9: Opened Conductor

Tools: Wire Cutter, Solder Station, Safety Glasses
Specification: Location; With Contact; Without Contact

The following procedure describes the method used to introduce unintended open circuited conditions in wire specimens. Select assembled wire harness and location where the open circuit defect is to be placed. Select particular wire that is to be electrically opened and use cutters to sever the wire. If no contact is specified cut off ¼-inch segment of the wire and cover with electrical tape. If contact is to be maintained between each side of the previously uncut wire, solder together the desired number of strands that correspond to the percentage of contact to be maintained and cover with electrical tape. For example, solder together half of the strands of each end of wire for fifty percent contact. Figure DT9-1 shows the tools needed to do the procedure. Figure DT9-2 shows the soldering together of wire strands and the resulting defects.

Figure DT9-1. Tools Needed for Opened Wire Conductor Defect

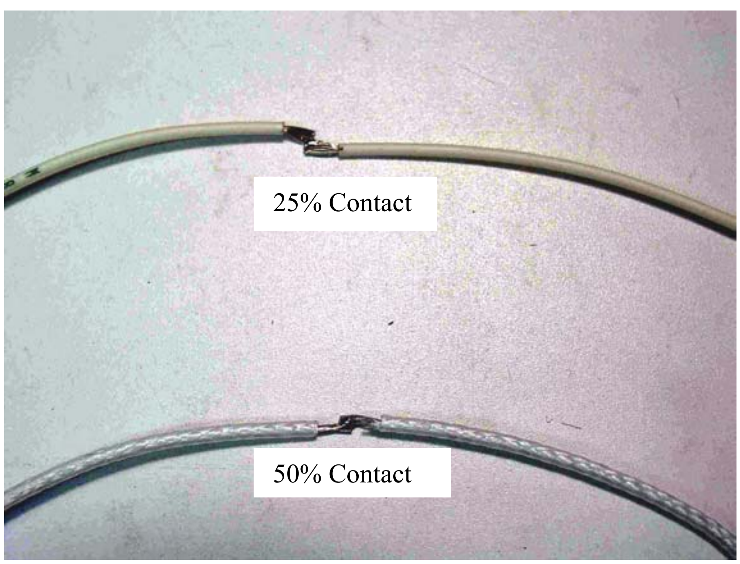
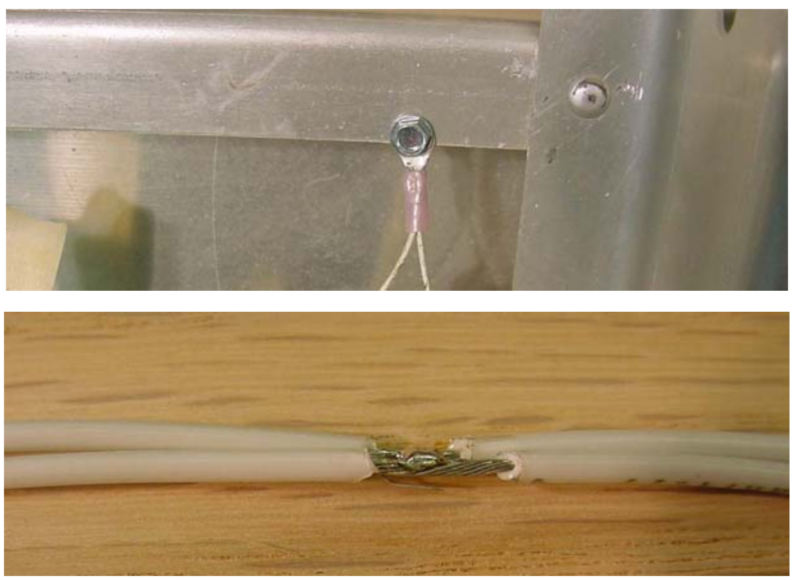


Figure DT9-2. 50 and 25 Percent of Varying Degrees of Contact

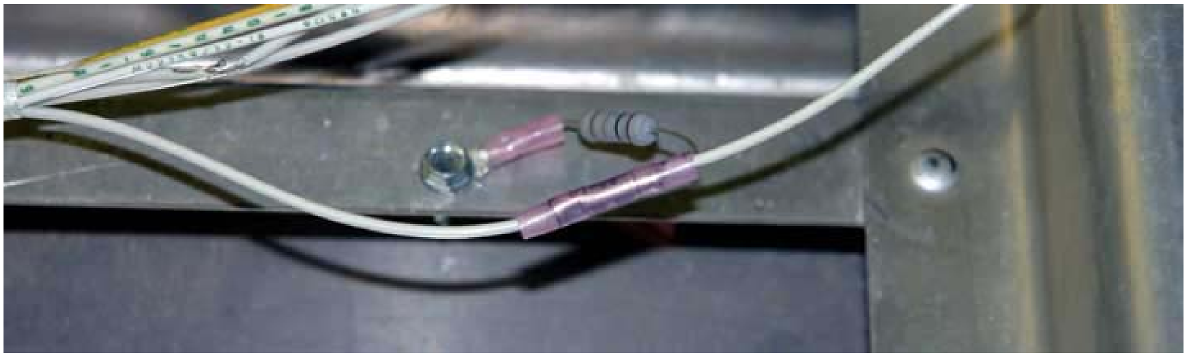
DT-10: Shorted Conductor

Tools: Wire Cutter, O-Lug, Crimper, Solder Kit, Safety Glasses, Sheet Metal Screw, Power Screw Driver, Safety Glasses, Resistors
Specification: Location; Short Path (Differential or Common Mode)

The following procedure will describe two methods used to introduce unintended short-circuited conditions in wire specimens. Select wire specimen and short location. The first method is a wire shorted to the enclosure frame (common mode). Cut wire and crimp on O-lug. Use a sheet metal screw and power drive to attach lug to enclosure frame. The second method uses the lateral breach procedure provided in section DT-2 to remove a segment of insulation of two adjacent wires and then a solder joint to short the two wires together (differential mode). Figure DT10-1 shows both wire short types. The severity of both types of shorts can be varied by soldering resistors of varying ohmic values between the ends of the short. This is shown in Figure DT10-2.



DT10-1. Photographs of Two Short Types



DT10-2. Resistor Used to Simulate a Partial Short

Annex F
Photographs of Defect Types Used in the Test Bed

This annex provides photographs of all defect types used in the test bed. Both naturally occurring and fabricated defects are shown.

Chaffed Defects (DT-1)

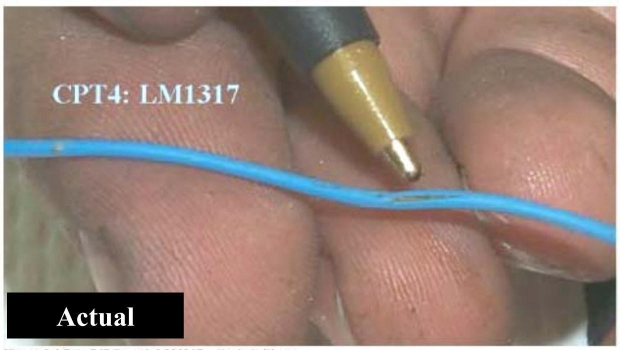
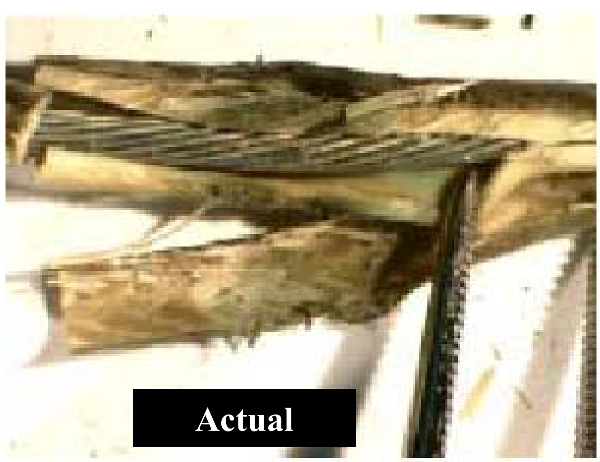
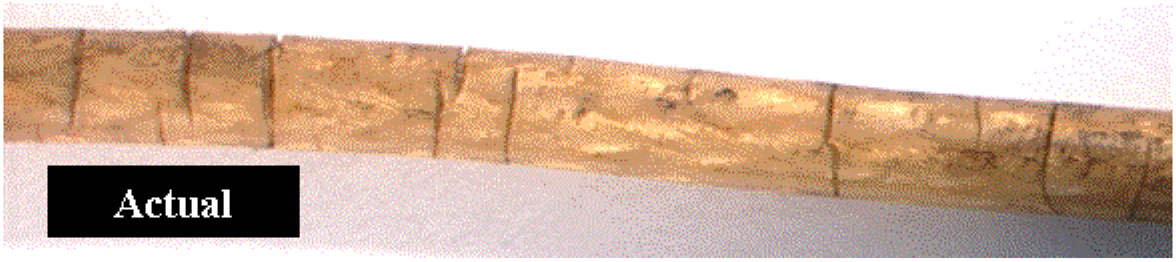


Figure 3.1.7-6. 747 Breach LM1317 – Cockpit Floor.

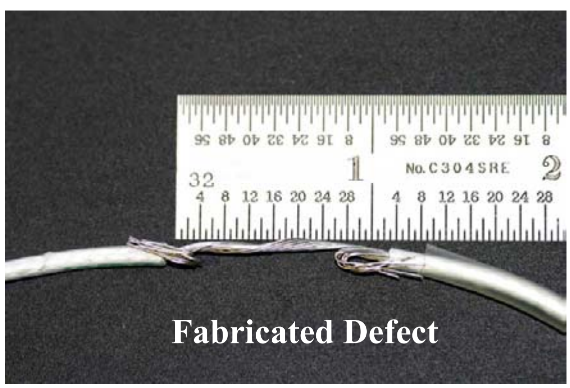
Breach Defects (DT-2)



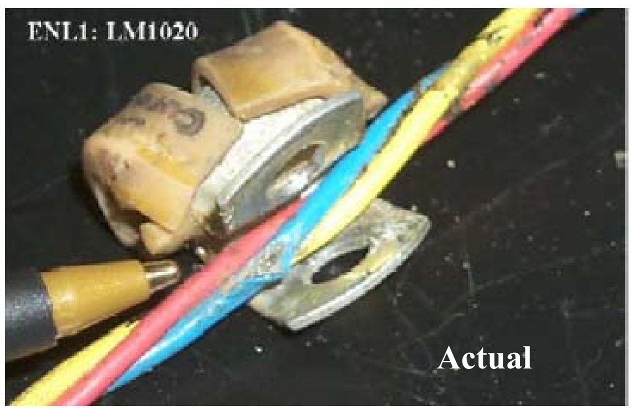
Cracked Defects (DT-3)



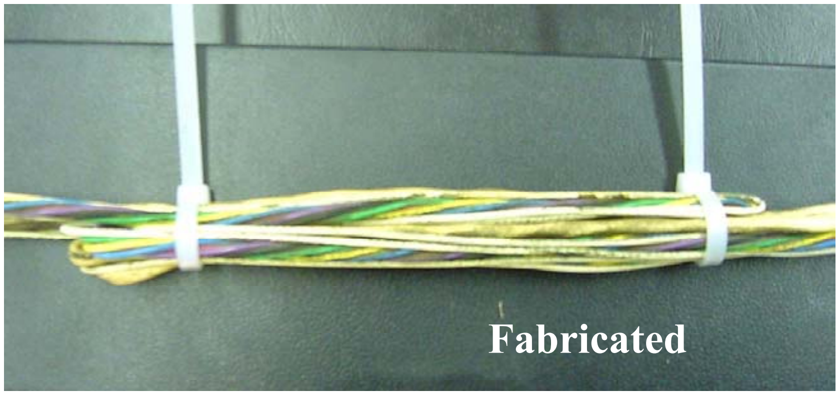
Conductor Strand Break Defects (DT-4)



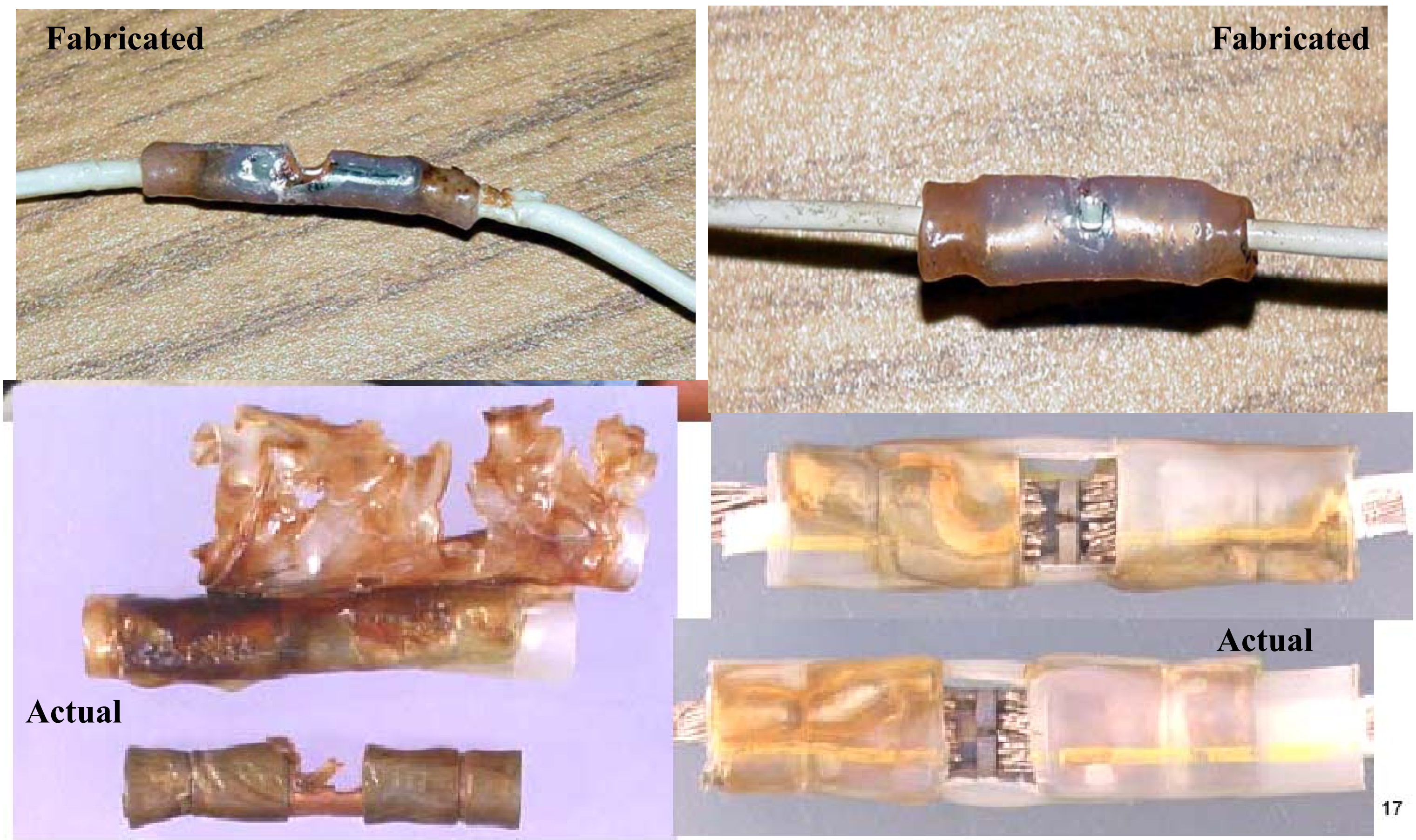
Over-Pressured Clamps Defects (DT-5)



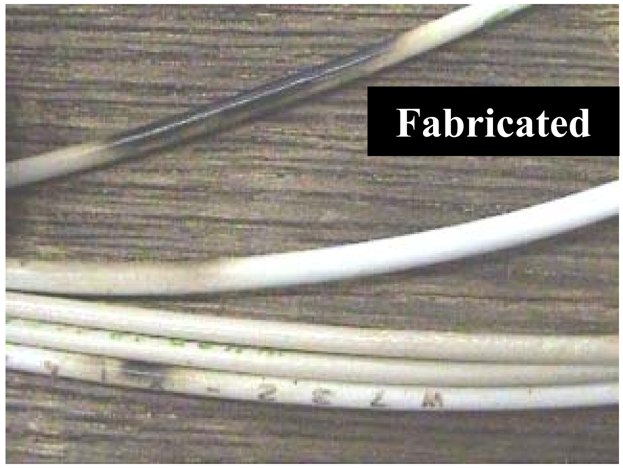
Excessive Bend Radius Defects (DT-6)

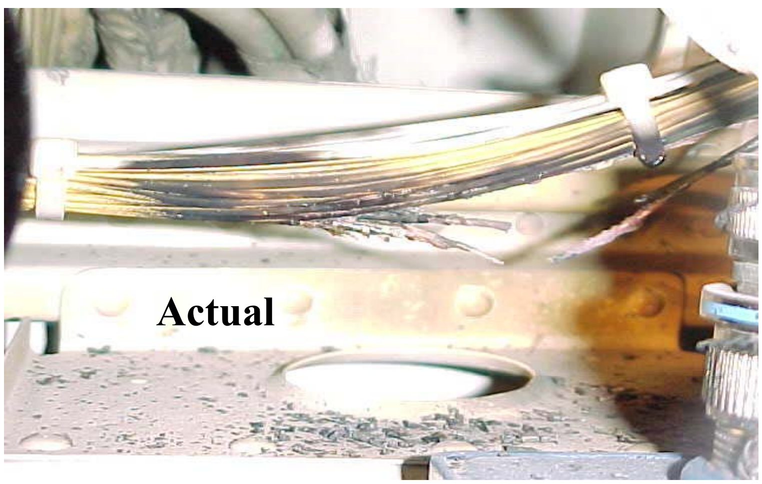


Faulted Splice Defects (DT-7)

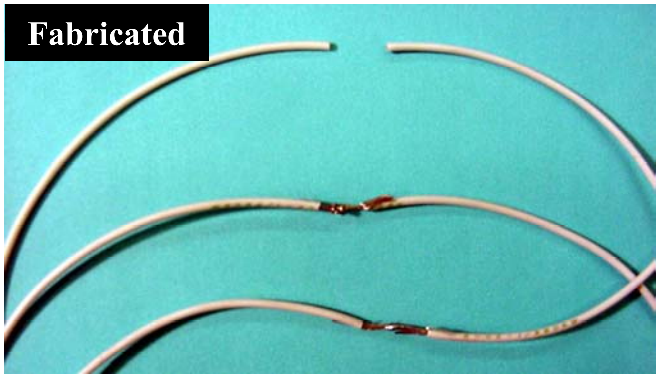


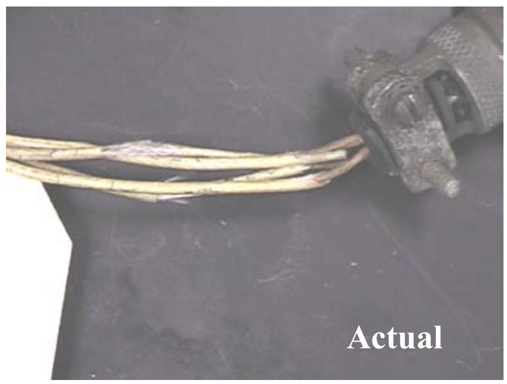
Charred Insulation Defects (DT-8)



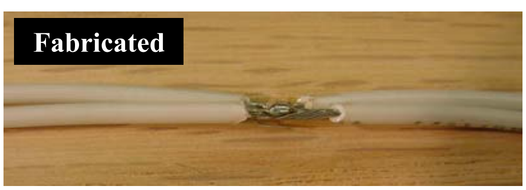


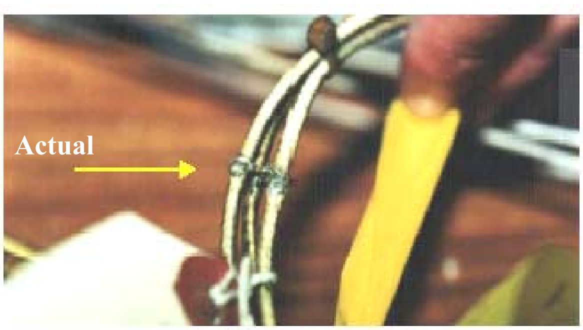
Conductor Opened Defects (DT-9)





Conductor Shorted Defects (DT-10)



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